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Editorial

Guglielmo Marconi

THE passing of the inventor of radio-telegraphy marks an epoch in the history of the human race. Some may attempt to belittle the greatness of his invention by referring to the work of Maxwell, who might almost be said to have evolved electromagnetic waves by the mental processes of his giant mind, or of Hertz, the brilliant mathematical and experimental physicist who first demonstrated their reality, or of others like Lodge, who continued and developed the experiments of Hertz, or of Popoff, who not only erected an aerial and inserted a coherer between it and the earth in order to record lightning discharges, but pointed out that it could be used to transmit messages if one could devise a powerful enough transmitter. None of these things, however, detract one jot from the credit due to Marconi for the conception of the possibility of applying the Hertzian experiments which he had seen Righi demonstrate at Bologna to practical telegraphy, and for the determined way in which he set to work to overcome experimental difficulties and make his dream come true. He seemed to have a prophetic vision of the future of wireless; to him the attainment of a range of ten miles was merely an incentive to reach a hundred miles, and the spanning of the English Channel in 1899, a preliminary to an attempt on the Atlantic.

It is not easy, even for those of us who lived through it and took an interest in it, to go back in imagination to those days when Marconi, at that time only twenty-six but already world-renowned, proposed to build a transmitting station at Poldhu in Cornwall of a power beyond anything previously attempted and try to transmit signals to America. The station was built with little delay and Marconi went to St. John's, Newfoundland to listen for the pre-arranged "S" signals—and heard them, to the confounding of the scientifically wise and prudent. The scientific opinion of the whole world was against him, and with good cause, for were not the waves of the same nature as light waves and like them travelled in straight lines? It is true that there would be a slight bending due to diffraction but not enough to produce any appreciable effect on the far side of that huge mountain of sea water. It was little wonder that the reports of his success met with considerable incredulity and the dots which he heard, attributed to atmospherics, but Marconi was in no doubt and the scientific world gradually became converted to the fact that the waves did bend round the earth to an extent far beyond that given by the simple theory. It was a case of Marconi versus the rest—and Marconi won, not because of any secret knowledge which he possessed and others did not, but because of his persevering faith in his own intuition. There was an element of truth in a remark that we once heard made by Professor Ayrton to the effect that if Marconi had known as much about electromagnetic waves as Sir Oliver Lodge he would never have attempted to span the Atlantic.

Then followed the long struggle to increase the reliability of the transatlantic service with the increase of wave-length, size of aerial, and power, and the heroic effort to obtain an approximation to a high-power continuous wave by means of the timed spark. The public service across the Atlantic was opened in 1907.

Then after the war one occasionally heard of amateurs working with powers of a few watts establishing communication with other amateurs in distant parts of the world by means of the despised short waves, which, being regarded as of no use for commercial purposes, had been given to amateurs to play with. It then transpired that Marconi had been making experiments with these waves, and once again he showed his intuitive faith and his readiness to stake his reputation on this new discovery by doing his utmost to stop the Government building the projected long-wave high-power station at Rugby, on the ground that it was already obsolete or would soon become so. This was the beginning of the rapid development of short-wave directional communication with all parts of the world.

Of the more personal side of his character we are not qualified to speak, but on the few occasions on which we came into personal contact with him we were much impressed by his simplicity and self-effacing modesty. His name will be for ever linked with the invention of what has proved to be one of the greatest triumphs of the human mind in the world of applied science.

G. W. O. H.

National Radio Show

THE annual Wireless Exhibition at Olympia, which closes on September 4th, has again provided an opportunity to examine the year's progress in the design of British broadcast receivers, television sets, and laboratory and testing equipment associated with design and maintenance. In next month's issue *The Wireless Engineer* will describe new technical features of receivers and those instruments, in particular, which make an appeal to the radio engineer.

Television receivers are a feature of the Show this year. It will be remembered that at last season's Exhibition not much enthusiasm had yet been kindled for the new service, but a year of experience and opportunity for development of receivers has produced more optimism, both on the part of the public and the manufacturer. A large number of receivers have been demonstrated to the public daily at Olympia, so that an opportunity has been provided for several thousand persons to see television, many for the first time.

A design for a receiver for experimental construction is shown on the Stand of *The Wireless World* and attracts special interest, as it is so placed that the details can be studied by visitors.

Among broadcast receivers the outstanding features are the increase in the number of models providing short-wave bands and the more liberal employment of valves, not so much to increase amplification as to provide for valve-operated refinements in control.

Resistance-Tuned Oscillators[*]

By W. G. Gordon, B.Sc., and R. E. B. Makinson, B.Sc.

1. Introduction

THE first suggestion of the possibility of tuning a circuit to resonance by variation of a resistance was made by Van der Pol[†] in a paper on circuit transformations. However, S. Cabot[‡] was the first to produce a practical circuit (Fig. 3) whose resonant frequency could be altered by varying a resistance. He dealt mainly with this circuit as an amplifier, but mentioned also the possibility of using it as a resistance-tuned oscillator.

It is the object of this paper to point out three transformations of Cabot's circuit with similar properties; to derive the conditions for oscillation and the frequency ranges of these when the losses and stray capacities are zero, and to show the effect of coil resistance and stray capacity in limiting, in practice, the actual frequency range obtainable. A practical form of oscillator is briefly described and the use of such circuits for producing frequency-modulated oscillations is pointed out.

2. The Principle of Resistance-Tuned Oscillators

Suppose a pure resistance $R(\omega)$, which is a function of the angular frequency ω, and is negative, to be connected in a closed circuit with an ordinary positive resistance R_1 (Fig. 1). Then oscillation will occur if the total series resistance becomes zero, i.e., if

$$R(\omega) + R_1 = 0 \qquad \ldots \quad \ldots (1)$$

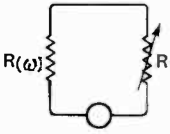
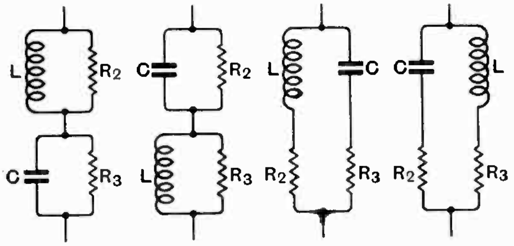


Fig. 1.

The frequency of the oscillation is obtained by solving this equation for ω, and may be varied over a certain range by varying R_1. Networks can be set up which under certain conditions behave as pure negative resistances of value depending on the frequency. Four such are shown in Fig. 2; that marked (a) is the one used by Cabot in his resistance-tuned amplifier (Fig. 3), R_3 being a negative resistance approximately equal in magnitude to R_2 and $\sqrt{(L/C)}$. The combinations (c) and (d) may be regarded as derived from (a) and (b) by a process of inversion,[§] in which "series" and "parallel," "inductance" and "capacity," are interchanged in the descriptions of the inverse circuits.



(a) (b) (c) (d)

Fig. 2.

Their impedance functions may be obtained from that of (a) by simple substitutions, so only the latter will be given.

3. The Impedance Function for Fig. 2 (a)

The impedance of the combination is

$$Z = \frac{R_2 L\omega j}{R_2 + L\omega j} + \frac{R_3/C\omega j}{R_3 + 1/C\omega j}$$

$$= \frac{(R_2 + R_3)L/C + j(L\omega - 1/C\omega)R_2R_3}{(R_2R_3 + L/C) + j(R_3L\omega - R_2/C\omega)}$$

$$= \frac{A + jB}{C + jD} \text{ say,}$$

$$= \frac{(AC + BD) + j(BC - AD)}{C^2 + D^2},$$

which will be *purely resistive* if

$$BC - AD = 0.$$

This can be satisfied for *all frequencies* if $C = A = 0$,

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[*] MS. accepted by the Editor, March, 1937.

[†] Balth. Van der Pol, *Proc. I.R.E.* 18 (1930), 221–230.

[‡] S. Cabot, *Proc. I.R.E.* 22 (1934), 709–731.

[§] T. E. Shea, "Transmission Networks and Band Pass Filters," p. 131.

i.e., if

$$\left.\begin{aligned} R_3 &= -R_2 \\ R_2 &= \sqrt{(L/C)} \end{aligned}\right\} \quad \ldots \quad \ldots \quad \ldots \quad (2)$$

When these conditions obtain, the equivalent resistance of the combination is B/D, or

$$R_a(\omega) = \frac{LC\omega^2 - 1}{LC\omega^2 + 1}\sqrt{\frac{L}{C}} = \frac{L\omega - 1/C\omega}{L\omega + 1/C\omega}\sqrt{\frac{L}{C}} \quad \ldots \quad (3)$$

Thus we have a pure resistance which is a function of frequency and is negative for a frequency range given by

$$0 < \omega < \frac{1}{\sqrt{(LC)}}.$$

4. Effective Resistance of the Derived Networks (b), (c), (d) of Fig. 2

The network (b) is simply (a) with L and C interchanged; the equivalent resistance is obtained by interchanging $1/C\omega$ and $-L\omega$ in (3) (the conditions (2) again holding), and is the negative of that given by (3).

Circuits (c) and (d) are derived from (a) and (b) (in which (2) applies) by inverting the latter with respect to $R_2 = \sqrt{(L/C)}$. The equivalent resistances of networks (c) and (d) are then the reciprocals of those of (a) and (b) multiplied by the square of the inverting constant R_2.

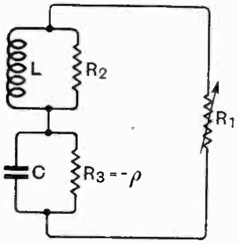

Fig. 3.—*Cabot's resistance-tuned circuit. A dynatron is used as the negative resistance* R_3; $R_2 = \rho = \sqrt{(L/C)}$.

Summarising these results, when the conditions (2) hold

$$\left.\begin{aligned} R_a(\omega) &= \frac{LC\omega^2 - 1}{LC\omega^2 + 1}\sqrt{\frac{L}{C}} \\ R_b(\omega) &= \frac{1 - LC\omega^2}{1 + LC\omega^2}\sqrt{\frac{L}{C}} \\ R_c(\omega) &= \frac{1 + LC\omega^2}{1 - LC\omega^2}\sqrt{\frac{L}{C}} \\ R_d(\omega) &= \frac{LC\omega^2 + 1}{LC\omega^2 - 1}\sqrt{\frac{L}{C}} \end{aligned}\right\} \quad \ldots \quad \ldots \quad (4)$$

5. Frequency Ranges

Having obtained networks which behave as pure negative resistances whose values are functions of the frequency, we may use them to obtain resistance-tuned oscillators as explained in § 2, replacing $R(\omega)$ of Fig. 1 by one of the four combinations of Fig. 2.

TABLE I

Oscillator derived from Fig. 2.	Frequency of Oscillation.	Frequency Range.
(a)	$\omega = \sqrt{\dfrac{R_2 - R_1}{(R_2 + R_1)LC}}$	$\begin{cases} R_1 = 0, & \omega = 1/\sqrt{(LC)} \\ R_1 = R_2, & \omega = 0 \end{cases}$
(b)	$\omega = \sqrt{\dfrac{R_2 + R_1}{(R_2 - R_1)LC}}$	$\begin{cases} R_1 = 0, & \omega = 1/\sqrt{(LC)} \\ R_1 = R_2, & \omega = \infty \end{cases}$
(c)	$\omega = \sqrt{\dfrac{R_1 + R_2}{(R_1 - R_2)LC}}$	$\begin{cases} R_1 = \infty, & \omega = 1/\sqrt{(LC)} \\ R_1 = R_2, & \omega = \infty \end{cases}$
(d)	$\omega = \sqrt{\dfrac{R_1 - R_2}{(R_1 + R_2)LC}}$	$\begin{cases} R_1 = \infty, & \omega = 1\surd/(LC) \\ R_1 = R_2, & \omega = 0 \end{cases}$

Substituting the expressions (4) in turn for $R(\omega)$ in the general relation (1), and solving for ω, we obtain expressions for the frequency of oscillation of the four circuits corresponding to Figs. 2 (a, b, c, d), as functions of R_1.

The range of the tuning resistance R_1 over which oscillations can occur in the cases (a) and (b) lies between zero and $R_2 = -R_3 = \sqrt{(L/C)}$, and in the cases (c) and (d) between R_2 and infinity. The corresponding frequency ranges are shown in Table 1.

6. Effect of Stray Capacities

It is found in practice that with the oscillators derived from Figs. 2(b) and 2(c) the frequency cannot be made to exceed a definite upper limit which is approximately the natural frequency of the coil L and the stray capacity C' across it. In Appendix I it is shown that this follows from the equations of the circuit in which R_1 shunts Fig. 2(b), when there is stray capacity across the coil, the tuning range then being given approximately by

$$\frac{1}{\sqrt{[L(C + C')]}} < \omega < \frac{1}{\sqrt{(LC')}} \quad \ldots \quad (4a)$$

In the case of the oscillators derived from 2(a) and 2(d) the minimum frequency obtainable in practice is greater than zero (See Appendix II). This is usually due to the finite reactance of the bypass condensers of the power supply, or of blocking condensers.

When there are losses and stray capacities in these oscillators the relations $R_2 = -R_3 = \sqrt{(L/C)}$ do not secure incipient oscillation, and one of the components, most conveniently R_2, must be adjusted slightly at each frequency if this condition is desired.

7. Practical Results

The oscillator derived from Fig. 2(b) has the convenient feature that the negative resistance may be the plate circuit of a reacting triode, as shown in Fig. 4 (unspecified capacities are blocking condensers of sufficiently high value). With a particular triode and the values of L and L' used the negative resistance obtained was of the order $-$ 3,000 ohms. The curve of frequency as a function of the resistance R_1 is shown in Fig. 5; this range is not large owing to the high stray capacity of the coil L, and to the fact that L' had to be large and closely coupled to L to obtain the required low negative resistance. Using a better coil designed to have a low capacity a frequency range of from 500 to 1,400 kc/s was obtained.

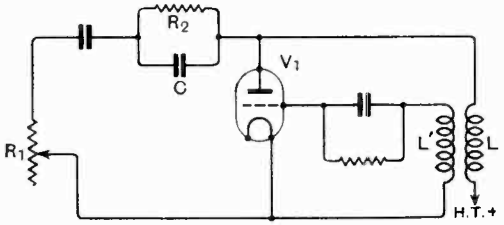

Fig. 4.—*A practical form of oscillator, based on Fig. 2 (b).*

According to the simple theory the circuit of Fig. 4 should generate a frequency tending to infinity as R_1 reaches 3,000 ohms, and for higher R_1 cease to oscillate. Actually it still oscillates when $R_1 > 3{,}000$ ohms, the frequency tending asymptotically to the natural frequency of the coil shunted by the stray capacity C' as R_1 increases. It will be noticed that when R_1 is very large the circuit approximates to an ordinary tuned plate triode oscillator, so this result is to be expected. The frequency ranges of oscillators of types (b) and (c) thus depend on the ratio of C/C' increasing with it.

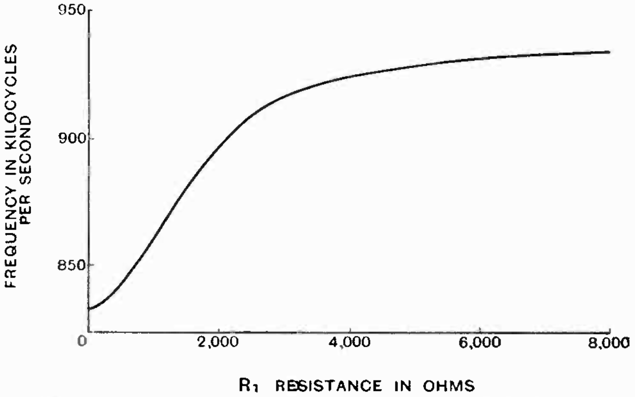

Fig. 5.—*Relation between frequency of oscillation and R_1 found with the circuit of Fig. 4.*

From the relations (2) expressing the conditions for oscillation in the ideal circuits it is seen that for a given value of negative resistance R_3 and a given minimum frequency L and C are automatically fixed ($C = -1/\omega R_3$, $L = -R_3/\omega$); and from (4a) that the ratio of maximum to minimum frequencies obtainable falls off at high frequencies, since the stray capacity across the negative resistance is irreducible.

To attain a high C/C' ratio, the magnitude of the negative resistance R_3 must therefore be as small as possible. The lowest values obtainable are about 2,000 ohms with a reacting triode, 8,000 ohms with a dynatron, and 4,000 ohms with a 6C6 type pentode tube, and it is found that C/C' falls to unity at about 2 Mc/s, setting approximately that limit to the frequencies obtainable from oscillators of this type.

The maximum frequencies obtainable with circuits (a) and (d) are limited in a similar way by stray capacity and the least magnitude of the negative resistance available. For most practical purposes, however, higher frequencies can be obtained by frequency doubling or by using the beat principle. The necessary harmonics are easily obtainable by adjustment of R_2 or R_3.

Circuit (c) is not of great practical use, due to the position of the negative resistance in the circuit. In order to feed D.C. potential to the valve forming the negative resistance a parallel feed system is necessary. With choke decoupling it was found very difficult to prevent oscillations in the choke circuit, while with resistance feed "squegging" developed. This instability is due to the high L/C ratios and the low negative resistances required in resistance-tuned oscillator circuits. The oscillators derived from (a) and (b) and (d) of Fig. 2 can be series fed with D.C. potential, and no trouble was experienced in getting them to work.

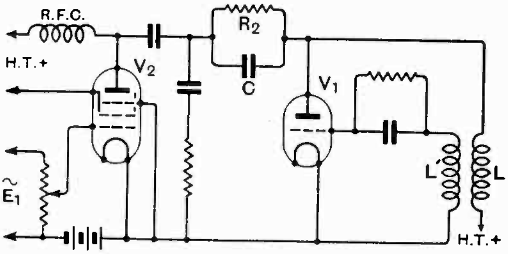

Fig. 6.—*A circuit for frequency-modulated oscillation, developed from Fig. 4.*

Since the frequency of oscillation of these circuits depends on the negative resistance R_3, which in turn is dependent on the supply voltages, the frequency stability cannot be expected to be very good. They are therefore only useful when high frequency stability is not of paramount importance, but their special properties offer advantages in certain applications.

For instance, in one of the oscillators tested it was possible to vary the frequency from 470 to 2,750 c/s by merely varying the tuning resistance from zero to 10,000 ohms. To cover the same range with an oscillator of the conventional type would necessitate the switching of large capacities, while a beat frequency oscillator is considerably more expensive to construct.

The most important application of these circuits lies in a new method* of obtaining frequency modulation by purely electrical means. The usual method is by mechanically varying an inductance or capacity of the oscillatory circuit; the Miller effect has also been used to obtain an electrically variable capacity. The difficulty with the latter method is that the possible change in the input capacity of a triode is not great, so that the amplitude of frequency modulation obtainable by this means is small, especially at low frequencies.

The anode-cathode differential resistance of a valve can in certain types be varied within wide limits by varying the control grid voltage. Using such a valve V_2 as part of the tuning resistance of the circuit shown in Fig. 6 the frequency of oscillation can then be modulated electrically by varying E_1, the control grid potential of V_2. Fig. 7 shows the frequency as a function of the control potential of the "resistance" valve in one such oscillator.

This system of frequency modulation has been made use of by one of the authors in apparatus for tracing out the selectivity curves of radio receivers on the screen of a cathode ray oscillograph; details of this apparatus will be published later. It is clear that response curves of many kinds may be traced in the same way, even when the frequency range required is quite large.

The experimental work described above was carried out by one of the authors (W.G.G.) in the laboratories of the Commonwealth Radio Research Board in Sydney.

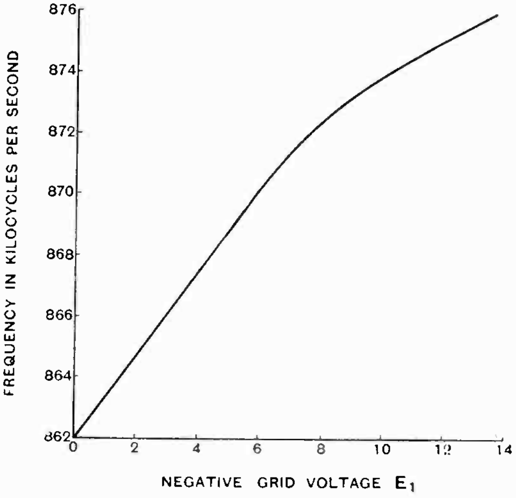

Fig. 7.—*Relation between the control potential E_1 in Fig. 6 and the frequency of oscillation.*

The authors wish to thank Professor J. P. V. Madsen for his continued encouragement and advice.

APPENDIX I

Limitation of Frequency Range by Stray Capacity.

In the circuit of Fig. 8, which is derived from Fig. 2 (b), there is a stray capacity C' across the

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* British Patent Specification 452,080, Dec. 29th, 1934.

inductance L. We have for the state of incipient oscillation

$$R_1 + \frac{1}{j\omega C + 1/R_2} + \frac{1}{1/j\omega L + j\omega C' + 1/R_3} = 0,$$

or

$$\omega^3 j(R_1R_2R_3LCC') + \omega^2[LC'R_3(R_1 + R_2) + LCR_2(R_1 + R_3)] - \omega j[R_1R_2R_3C + L(R_1 + R_2 + R_3)] - R_3(R_1 + R_2) = 0,$$

resulting equation is complicated we may assume for simplicity that $C' << C$, when (8) gives approximately $R_2 = \rho = \sqrt{(L/C)}$. We then have from (9), when $R_1 = 0$

$$\omega = \frac{1}{\sqrt{[L(C + C')]}},$$

and when $R_1 = \rho$

$$\omega = \frac{1}{\sqrt{(LC')}}.$$

Thus the maximum frequency attainable is that at which L and C' resonate, and a low C/C' ratio limits considerably the possible frequency range.

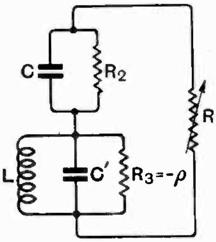

Fig. 8.

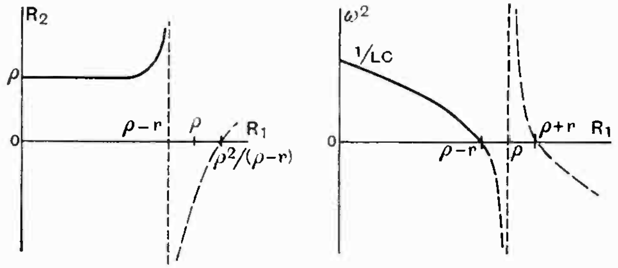

Fig. 9.—*Showing the necessary value of R_2 as a function of R_1 and the dependence of ω^2 on the latter.*

Hence

$$\omega^2 = \frac{R_1R_2R_3C + L(R_1 + R_2 + R_3)}{R_1R_2R_3LCC'} \quad \ldots \quad (5)$$

and $\omega^2 = \dfrac{R_3(R_1 + R_2)}{L[C'R_3(R_1 + R_2) + CR_2(R_1 + R_3)]}$ (6)

Eliminating ω^2 we have as a condition for oscillation at the frequency given by (5) or (6)

$$(R_1 + R_2)CC'R_1R_2R_3^2 = [CR_1R_2R_3 + L(R_1 + R_2 + R_3)] \times [C'R_3(R_1 + R_2) + CR_2(R_1 + R_3)] \quad \ldots \quad (7)$$

We now suppose that R_3, L and C are fixed, and

$$R_3 = -\sqrt{(L/C)}$$
$$= -\rho \text{ say,}$$

and that when the frequency is adjusted with R_1 the point of oscillation is maintained by adjustment of R_2. Then from (7)

$$(R_1 + R_2)\rho R_1R_2C' = [R_1R_2 - \rho(R_1 + R_2 - \rho)] \times [C'\rho(R_1 + R_2) - LR_2(R_1 - \rho)/\rho^2]$$

or

$$R_2^2[L + \rho^2C' + R_1L(R_1 - 2\rho)/\rho^2] + R_2[\rho^2C'(2R_1 - \rho) - (R_1 - \rho)^2L/\rho] + C'R_1\rho^2(R_1 - \rho) = 0 \quad \ldots \quad (8)$$

and from (6)

$$\omega^2 = \frac{\rho(R_1 + R_2)}{L[C'\rho(R_1 + R_2) - LR_2(R_1 - \rho)/\rho^2]} \quad (9)$$

The value (8) gives for R_2 as a condition for incipient oscillation is to be substituted in the equation (9) for ω^2, which then gives the range the latter can have for variation of R_1, subject to the conditions $R_1 > 0$, $R_2 > 0$, $\omega^2 > 0$. As the

APPENDIX II

Effect of Coil Resistance on the Frequency Range.

When the oscillator has the form of Fig. 3, but the coil L has a resistance r, the equation for oscillation is

$$R_1 + \frac{(j\omega L + r)R_2}{R_2 + r + j\omega L} + \frac{1}{j\omega C - 1/\rho} = 0,$$

giving on separation of real and imaginary parts

$$R_1(R_2 + r) + (R_1 + R_2)\rho LC\omega^2 + rR_2 - \rho(R_2 + r) = 0 \quad \ldots \quad (10)$$

and

$$R_1(R_2 + r)\rho C + rR_2\rho C + (\rho - R_1 - R_2)L = 0 \quad (11)$$

As before, we suppose ρ, L and C to be fixed, with $\rho = \sqrt{(L/C)}$ and R_2 to be adjusted to keep the circuit on the point of oscillation. Then from (11)

$$R_2 = \frac{(\rho - r)R_1 - \rho^2}{r - \rho + R_1} \quad \ldots \quad (12)$$

Substituting in (10) we obtain

$$\omega^2 = \frac{(\rho - R_1) - r^2/(\rho - R_1)}{\rho + R_1}\,\frac{1}{LC} \quad \ldots \quad (13)$$

In Fig. 9 the relations (12) and (13) are sketched, showing the necessary value of R_2 for each setting of R_1, and the dependence of ω^2 on the latter. The negative values of R_2 and ω^2 are inadmissible; R_2 must be infinite when $R_1 = \rho - r$ at $\omega = 0$.

The inclusion of the coil resistance r thus prevents the frequency range from extending down to zero if R_2 cannot be made high enough to satisfy the condition for oscillation at the lower frequencies.

Detection by Diodes and Triodes at High Frequencies*

By W. E. Benham

SUMMARY.—Some 1926 experiments on the detection of unmodulated carriers, the frequency of which was varied from zero up to about ƒ24 Mc/s., receive a measure of explanation in the light of revised theoretical conclusions. An exhaustive study of the second harmonic, as produced by the valve from an input signal initially sinesoidal, leads broadly to the following conclusions. In the case of a diode with zero anode circuit load, a decrease in the absolute value of the detection coefficient is predicted, whatever the space charge conditions, as the frequency of the incoming signal increases. The effect is small in a parallel plane diode, but quite marked in a cylindrical diode with thin filament. Experimental results on filamented cylindrical diodes show as good agreement with theory as could reasonably be expected.

In the case of triodes, tetrodes and pentodes a slightly different criterion must be applied in the determination of the detection coefficient, leading to marked differences in the solution. For a plane geometry an increase with frequency is predicted over the range $0 < \omega < \frac{3\pi}{2\tau_0}$, where τ_0 is the electron transit time between cathode and a surface slightly beyond the grid. The detection coefficient for $\omega\tau_0 = 3\pi/2$ is about 3.5 times its value at very low frequencies. The above remarks refer to anode bend detection, τ_0 being the electron transit time in the absence of signal. In the case of leaky grid detection a much smaller increase is to be expected, but this case is not considered. For a cylindrical geometry, the frequency characteristic rises, as in the plane case, if the cathode diameter is not too small in comparison with the diameter of the control grid, but for very small cathode diameters the frequency characteristic falls. Some early experiments on a Marconi DEV triode uphold the theoretical conclusions if we suppose that changes in the position of the potential minimum surface surrounding the filament are effective in altering the apparent geometry. Further experiments, particularly on indirectly heated valves, are desirable. Attention is called to a hysteresis phenomenon which can occur at low frequencies, in the case of valves having oxide coated cathodes, and which has nothing to do with the phenomena under investigation. A section is devoted to the somewhat surprising phenomenon of ultra top bend detection.

Certain resonance effects observed in 1926 are associated with the behaviour of the valve as the frequency of the signal generator passes through a value equal to half that to which the receiving circuit is tuned. A simple theory of this effect confirms that an oscillation of frequency 2ω will build up in a circuit tuned to this frequency, if a diode valve is presented with a signal of frequency ω. When the latter is removed the oscillation dies down. The phenomenon is described as "driven instability," and is to be distinguished from that of "oscillation hysteresis." It would appear incidentally that the use of frequency doubling in radio transmitters has never been fully understood.

Introduction

If the input signal to a diode is initially free from harmonics, it will not remain so when the diode is made conducting by heating the cathode. Harmonics arising within the diode circulate through the input circuit, so that the input signal becomes, in effect, a distortion of its original pure sine form.

In the analytical treatment of the electron motions in the diode, it is convenient to distinguish two cases of importance among the infinite variety that can arise under practical conditions. These two cases are as follows.

(A) Input signal, under operating conditions, is supposed free from harmonics.

(A') The applied potential, when averaged over a cycle of the received signal, does not alter from the d.c. value impressed between cathode and anode.

The above conditions are mutually exclusive, *i.e.*, cannot both be satisfied together.

From the opening paragraph it will be evident that condition A is not normally satisfied. When, however, we replace our diode by a triode, tetrode or pentode, it is possible to satisfy condition A to a close approximation. This is owing to the separation of input and output circuits.

Condition A' is the one to use in the case of actual diodes, though this condition

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* MS. accepted by the Editor, July, 1937.

applies exactly only in cases where the load resistance is zero.* The mean inter-electrode potential is then maintained equal to that of the source of D.C. potential; no "rectified" potential is possible, since the load resistance has been taken as zero.

Anode Bend Detection

Curve *A* of Fig. 1 represents the detection coefficient, in terms of unity low frequency value, in the case where condition *A* is satisfied. A plane geometry is assumed. In application to triodes, tetrodes and pentodes a bye-pass for the second harmonic (also given by curve A) would normally be afforded by the provision of a suitable condenser between anode and cathode. For negligible D.C. load in the anode circuit the frequency characteristic of the detection coefficient is still given by curve *A*, and as the optimum load (for a triode) would be given approximately by $r_p/5$, it is not far from the truth to take curve *A* as the frequency characteristic under optimum detection conditions. For a cylindrical geometry, the frequency characteristic of anode bend detection lies somewhere between curve *A* and curve *B*, which represents the hypothetical extreme of infinitely small filament. In Fig. 1, τ_0 represents the electron transit time in the absence of signal. In the case of diodes this transit time is reckoned between cathode and anode, but in all other cases τ_0 is reckoned between cathode and a surface just beyond the grid.

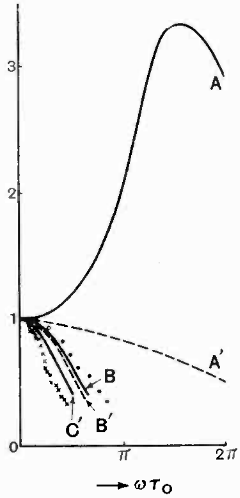

Fig. 1.—*Second order solution, plane and cylindrical diode. A, rectified current (= modulus of second harmonic total current) for input potential free from second harmonic (planes). A', rectified current for no change in D.C. potential between electrodes (planes). B, curve corresponding to A, but for cylinders with infinitely fine filament. B', curve corresponding to A', but for cylinders with infinitely fine filament. C, rectified current for harmonic free input potential, emission limited condition (planes). x, typical experimental points for top-bend rectification (cylindrical diode). o, typical experimental points for bottom bend rectification (cylindrical diode). All quantities are referred to unit low frequency value. Actual sign of rectification is negative for curve C and points x, positive in all other cases.*

Diodes require in general curves *A'*, B'. While the presence of anode circuit load would cause departures from these curves, the inclusion of such load in addition to electron transit time considerations is thought not to be warranted. The theory would become more difficult, and, though this may be a personal preference, I would always use tetrodes or pentodes as detectors except perhaps in television work. The experiments cited in the sequel were carried out with zero anode circuit resistance to afford comparison with theory.

Fig. 1 supersedes all previous second order solutions. In earlier work it was assumed that the applied potential, averaged over a cycle, could be arrived at by integration over the interelectrode space of the (time averaged) value of the electric field. More refined analysis[1] reveals that this is an approximation too severe to be tolerated. The fact that the approximation[2] was passed by B. D. H. Tellegen[3] and repeated by R. F. J. Jarvis[4] and F. B. Llewellyn[5] serves to indicate the difficulty which the second order solution has presented in the past. A greatly simplified treatment is fortunately now possible, providing complete information as to the first, second and third harmonics, including the third order contribution to the first harmonic, in a plane diode, whether space charge or temperature limited.

Curve *C'* of Fig. 1 corresponds to the type of detection which can occur on the flat part of the anode current-anode volts characteristic. The detection coefficient is negative in this case, but, as in the case of the other curves, *C'* corresponds to the frequency characteristic referred to its low frequency value as unity. These questions are resumed in a later section.

The detection sensitivity of a diode is an

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* The case where the load resistance is very high, so that no second harmonic current can flow, is amenable to treatment. The rectified potential decreases with frequency according to the factor $\left[1-\frac{11}{200}(\omega\tau_0)^2+\frac{13}{5000}(\omega\tau_0)^4-\ .\ .\ .\right]$ for plane electrodes and $\left[1-\frac{509}{2052}(\omega\tau_0)^2+.0204(\omega\tau_0)^4\right]$ for cylindrical electrodes $\left(\frac{b}{a}>>1\right)$.

optimum in the case of zero anode volts. Under these conditions, unfortunately, an estimate of electron transit time is a matter of some difficulty. The points o on Fig. 1 are for a diode with zero anode volts, an estimate of τ_0 being made by assuming the electrons to travel with constant velocity, determined by the filament temperature. If the filament of the valve had been infinitely fine, curve B' would be the theoretical curve for this case. The departure of the points o from curve B' is in the direction required by the fact that the experimental structure is intermediate between the two theoretical extremes A' and B'.

The points x on Fig. 1 correspond to top-bend rectification. No theoretical curve has been worked out for this case. As it well known, the shape of this bend is determined by the initial velocity distribution.

Points corresponding to ultra-top bend detection are not shown on Fig. 1 as they lie very close to the initial portion of the curve C', and would hardly be distinct enough to be seen.

Some instructive results[6] on a Marconi DEV triode as anode bend detector are reproduced on Fig. 2. The paucity of points is explained by the fact that these results were at the time intended merely as a rough check on the minimum anode voltage for which the triode could be operated as valve voltmeter free from frequency error. The input potential was maintained at a given value at each frequency by means of a Dolizalek electrometer known to be free from frequency error over the range 0 — 24 Mc/s. (this result had been established during earlier work with diodes).

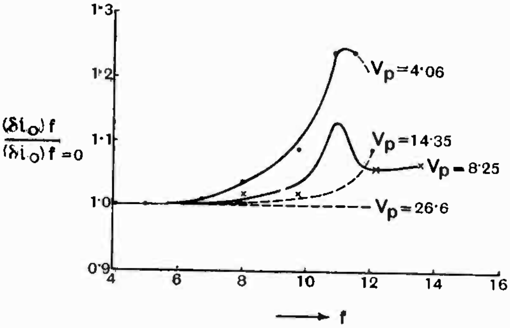

Fig. 2.—*Rough check on Marconi DEV triode as anode bend detector. Grid bias zero. Vp = anode voltage, f = frequency in megacycles.* 9.12.26.

The humps appearing on Fig. 2 suggest that the filament-grid geometry resembles a plane geometry sufficiently for the hump feature of curve A (Fig. 1) to be apparent. The heights of the humps in Fig. 2 are, however, very much less than that of curve A. Thus, some intermediate theoretical curve, lying everywhere between curves A and B of Fig. 1, would possibly explain the experiments quite well. On this basis, however, should we not expect the hump for V_p8 (Fig. 2) to be the same as that for V_p4? At first sight this consideration seems to rule out a purely "transit-time" explanation. When, however, it is considered that the lumped potential at the grid surface is almost zero in the case V_p4, it will be realised that the potential minimum surface must be of considerably larger radius than the filament. As the anode voltage is raised the potential minimum surface must close in on the filament. Thus, we have only to assume, as is reasonable, that the effective geometry of the valve is determined by taking the potential minimum as virtual emitter, and the reduction of hump with increase of V_p receives immediate explanation. Moreover, as the potential minimum moves inwards the electrons have a longer journey to perform. Thus the transit time (potential minimum to grid) will not necessarily decrease as the anode voltage V_p is raised from V_p4 to V_p8. This possibility is also suggested by the fact that the hump at V_p8 occurs at nearly the same value of f as the hump at V_p4, whereas a reduced transit time necessitates that the hump move to the right of the diagram as V_p is increased. The hump does appear to move to higher values of f as V_p is raised further to V_p14. For now the potential minimum would already be too close to the filament to move inwards much farther. For V_p26 there is no sign either of a hump or of increase with frequency. Higher frequencies would have been necessary in order to follow in detail the apparent change in geometry between the extremes A and B of Fig. 1, though owing to the finite filament diameter curve B would not be attained in practice. In conclusion of this section, it should be mentioned that the electron transit time effective in the case of V_p4 and V_p8 appears to be no less than 7.10^{-7} secs. It is owing to contact potentials and similar considerations that this thoriated filament valve cuts off in the neighbourhood of zero grid bias.

In modern valves having oxide coated cathodes, an oscillogram of the characteristic may reveal a hysteresis effect, which generally takes the form of a loop in the neighbourhood of maximum anode current. This effect which it is hoped to discuss elsewhere is not to be confused with the phenomena discussed in the present paper.

Ultra-Top Bend Detection

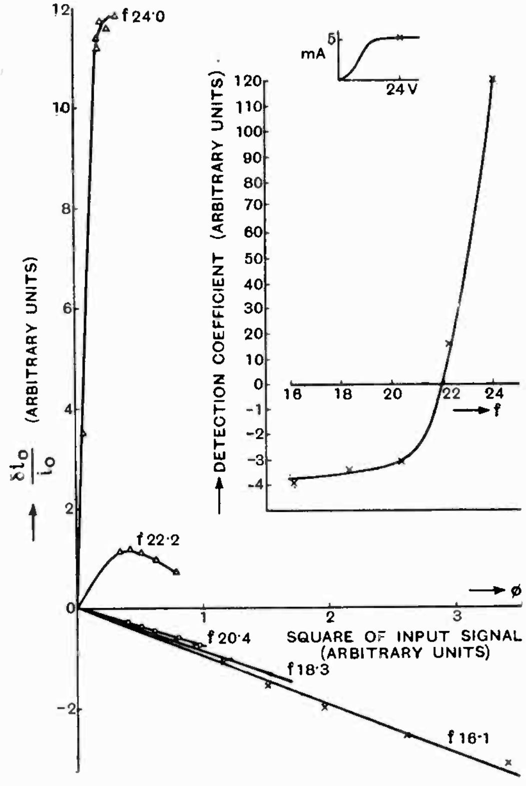

Fig. 3.—18.9.26.

Experiments on a bright emitter used as diode (grid and plate tied) are shown in Fig. 3. The detection coefficient is normally negative (f 16, 18 and 20), the change of sign in the cases f 22 and f 24 being "anomolous." There appeared to be no reasonable explanation, even of the "normal" results, until, quite recently, the following expression was derived for this case (plane diode)

$$\delta i_0 = -\frac{3 i_0 v_1^2}{16 v_0^2}\left[1 - \frac{5}{18}(\omega\tau_0)^2 + \frac{67}{2160}(\omega\tau_0)^4 - \ldots\right] \quad \ldots \quad (1)$$

The square bracket term is plotted as curve C' of Fig. 1. Equation (1) compares with the following expression for bottom bend detection as given by curve A' :—

$$\delta i_0 = +\frac{3 i_0 v_1^2}{16 v_0^2}\left[1 - \frac{7}{600}(\omega\tau_0)^2 + \frac{171}{140{,}000}(\omega\tau_0)^4 - \ldots\right] \quad \ldots \quad (1a)$$

Bearing in mind that i_0, v_0 will depend on the point chosen on the characteristic, we may say that at frequencies for which $\omega\tau_0 \leqslant 1$, the ultra-top bend detected current is given by the same expression as for bottom bend, but with a minus sign. This result is little short of remarkable.* It is to be emphasised that equation (1) and Fig. 3 refer exclusively to detection on the flat portion of the characteristic and not to detection at the top bend.

A simple explanation as to why detection is obtained on the flat portion may be of interest. It may be shown that a single electron in its passage between plane electrodes induces in the circuit immediately attached to the electrodes the current $\frac{e\dot{x}}{d}$, where e is the absolute value of electronic charge, $\dot{x}$ is the velocity at the point x where the electron happens to be, and d is the total distance between the planes. In terms of the electron transit time, since $\dot{x} \doteqdot \gamma\tau$, $d \doteqdot \frac{1}{2}\gamma\tau_d^2$, the current becomes $\frac{2e\tau}{\tau_d^2}$, where τ_d is the instantaneous electron transit time for the whole journey. When half the electron transit time has elapsed ($\tau = \frac{1}{2}\tau_d$) the induced current is given by $\frac{e}{\tau_d}$, and this is

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* Equation (1) is derived on the basis of no second harmonic either in the input voltage or in the space charge density, and these conditions are not easily reproduced experimentally. The detection coefficient at f 16.1 nevertheless agrees with equation (1) to within 3 % (N.B. $\omega\tau_0 = 0.1$ only). At higher frequencies the agreement is less close, due to the increase of second harmonic as f approaches 24 Mc/s (see later).

the average value of the induced current per electron. Now, if τ_d becomes shortened (due to a positive cycle of input signal) the induced current is increased, but since the electron transit time is connected with the electrode potential by a non-linear relation the rise and fall of current will not correspond in waveform to the rise and fall of the potential. The induced current per electron will, for an anode potential $v_0 + v_1 \cos \omega t$, be given approximately by

$$i_e = \frac{e}{\tau_d}$$

$$= \frac{e}{d}\left(\frac{ev_0}{2m}\right)^{\frac{1}{2}}\left(1 + \frac{v_1 \cos \omega t}{2v_0} - \frac{v_1{}^2 \cos^2 \omega t}{8v_0{}^2} + \ldots\right)$$

The last term gives rise to a term independent of t, negative in sign. The complete explanation, involving many electrons, is naturally more complicated. The extent to which we must revise our ideas in regard to total emission will be appreciated from the fact that the apparent direct current in Fig. 3, at f24Mc/s, reaches a value some 20 per cent. higher than the total emission. The contracted positive scale of the inset diagram, giving the detection coefficient is to be noted. No evidence for a rise in filament temperature was obtained, and it may be said that theory no longer requires such a rise.[7]

If the input waveform is not purely sinesoidal, but is given by $v_0 + v_1 \cos \omega t + v_2 \cos(2\omega t - \phi)$, the electron transit time can, for certain values of ϕ, be markedly shortened during positive peaks. In this way the value of i_e averaged over a cycle can exceed the value corresponding to v_0. The change in sign of the detection coefficient found experimentally (Fig. 3) must be due to the presence of considerable second harmonic. At f24 Mc/s. the receiving circuit is tuned to f48 Mc/s. and the second harmonic produced by the diode builds up a large potential. The following analysis throws some light on this phenomenon, a milder form of which appears on Fig. 4 (early run, top-bend detection).

Anomalous (Driven) Instability

Considering a diode for simplicity, let the input signal be initially free from harmonic. The diode will produce, in addition to fundamental current, i_1, some second harmonic current i_2, which returns via the input circuit and sets up the back e.m.f. i_2Z_2. We may write at this stage

$$v_2 = 0 - i_2Z_2$$

in which the zero reminds us that there was no second harmonic to begin with and that, therefore, we must now proceed to a higher degree of approximation, and regard the potential v_2 as part of the original signal. Thus v_2 will give rise to further current of second harmonic frequency (also to higher even harmonics, 4th, 6th . . . which need not concern us). In this way we obtain by successive approximations

$$v_2 = - i_2Z_2[1 - {}_1Y_2Z_2 + {}_1Y_2{}^2Z_2{}^2 - \ldots]$$

$$= - \frac{i_2Z_2}{1 + {}_1Y_2Z_2}$$

where ${}_1Y_2$ is the first order admittance of the diode to signals of double frequency. We may now define the apparent second order admittance of the diode as

$$Y_2 = \frac{i_2}{v_2} = - \frac{1 + {}_1Y_2Z_2}{Z_2}$$

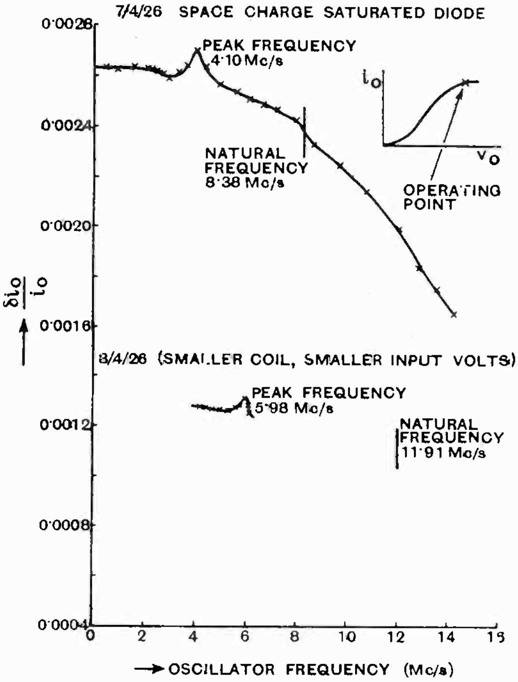

Fig. 4.—*R.M.S. input volts keep constant at each frequency.*

whence we readily find that for Z_2 either very large or very small, the real part of Y_2 is negative. In other words, however the input circuit is arranged (series or parallel resonance), if $4\omega^2LC = 1$ the apparent second harmonic conductance is negative. This means that second harmonic will build up, but it is necessary that the diode be continually supplied with signal of fundamental frequency.

In the case of frequency doubling circuits using triodes or pentodes, second harmonic is selected by the output circuit, the input circuit being tuned to fundamental. The problem of improving the efficiency of power stages operating as frequency multipliers is one of the important questions facing transmitter engineers at the present time. It is my belief that such improvement is possible, and the present article may provide some useful hints in this direction.

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1. W. E. Benham, forthcoming paper in *Proc. Inst. Rad. Eng.* See also *Nature*, 139, 591, April 3rd, 1937.

2. W. E. Benham, *Phil. Mag.*, V., 323, 1928 (experimental), *ibid* V, 641, 1928. See pp. 649 and 650.

3. W. E. Benham, *ibid.* XI, 457, 1931.

4. R. F. J. Jarvis, Ph. D. Thesis, University of London, 1932. See pp. 17 and 29 of Part II.

5. F. B. Llewellyn, *Bell S. Tech. Journ.*, XIV, pp. 644–646, 1935.

6. See p. 660 of ref. 2. It is noteworthy that some detection results by C. Protze (*Hochf:tech. u. Elek:akus.*, 42, 1, 20, 1933) indicate a rising frequency characteristic, even when the triodes were connected as diodes. Insufficient details were given and it is uncertain whether the arrangement conformed with condition A or with condition A' of the present paper. The results of J. Müller and F. Tank (*Helvet. Phys. Acta*, i, 447, 1928) on filamented cylindrical diodes showed at least qualitative agreement with my experiments and with the present theory, apart from anomalies at λ81 cm. At this very high frequency, however, the results may have been vitiated by a number of factors.

7. E. C. S. Megaw, *G.E.C. Journal*, VII, 2, May, 1936. See Fig. 11 and accompanying text. In Megaw's case the greater part of the rise in mean anode current is attributed to electron bombardment of the filament, but Megaw also states that " a part of this rise may be due to anode current flowing during a greater part of the H.F. cycle than at long wavelengths." I would have said here that " a part of the rise is due to the induced current reaching abnormally high values during a small fraction of the cycle."

Polytechnic Courses

A PROSPECTUS has been issued by the Electrical Engineering Department of the Polytechnic of the courses in Radio and Television Engineering for the Session 1937–38 which commences on September 20th.

The courses, which extend over a period of five years, provide a thorough training in the principles and technique of high-frequency engineering.

The prospectus is obtainable on application to The Polytechnic, 307–311, Regent Street, London, W.1, where enrolments will be taken from September 13th to 17th between 6 and 9 p.m.

The Industry

A BOOKLET dealing with the theory, construction and properties of electrolytic condensers has now been issued by Ferranti, Ltd., Radio Works, Moston, Manchester, 10. Primarily intended for radio engineers and designers, the publication is available at 1s. 6d. per copy, post free.

The assets of Musikon, Ltd., the well-known makers of home and professional gramophone recording apparatus, have been taken over by Will Day, Ltd., 19, Lisle Street, Wardour Street, London, W.C.

A slide rule designed essentially for calculations in electrical engineering is now available from the Dubilier Condenser Co., Ltd., Ducon Works, Victoria Road, North Acton, London, W.3, at the price of 39s. 6d. In addition to the usual features of a slide rule, it comprises fixed scales for voltage, frequency and wavelength and moving scales for capacity and current.

Théorie et pratique des Circuits Fondamentaux de la T.S.F.

By J. Quinet, pp. 431+VIII. 197 Figs. Dunod, 92 rue Bonaparte Paris 6. 120 fr.

This book, to which M. Gutton, the Director of the Laboratoire national de Radio-Électricité has written a preface, has as a continuation of the above title " Exposées par le calcul des imaginaires mis à la portée de tous avec de nombreux exemples numériques." The use of complex algebra in the solution of circuit problems has not been so common in France as in England and the States, and, as the author says, this method can be applied with advantage to nearly every circuit problem in which the radio-engineer is interested. Hence the slogan which appears on the wrapper : " La simplicité par les Imaginaires." After an introductory chapter explaining the various symbolic methods of representing vectors, the author applies the method to practically every circuit which occurs in radio telegraphy and A.C. measurement. The book is clearly written and will provide excellent material for those wishing to exercise themselves in the applications of the symbolic method.

G. W. O. H.

Characteristic Constants of H.F. Pentodes*

Measurements at Frequencies Between 1·5 and 300 Mc/s

By M. J. O. Strutt

(Natuurkundig Laboratorium der N. V. Philips, Gloeilampenfabrieken, Eindhoven, Holland)

I. What are the Constants Determining H.F. Action of Amplifier Tubes?

In the first place we have *input parallel resistance* and *input capacitance* of the tubes. This input parallel resistance is parallel to the input circuit and hence greatly affects its quality. Input capacitance limits the smallest possible circuit capacitance and hence the wave range obtainable with a given tuning condenser. Furthermore, variation of input capacitance by volume control causes detuning of the input circuit. Variation of input parallel resistance by volume control results in variable circuit quality and hence variable selectivity. Replacing a tube in a set by another one should result in small variation of these constants, if no fresh trimming is desired in such a case.

Much the same can be said of the *output parallel resistance* and *output capacitance* of a tube, as they are also parallel to a circuit.

In the third place, *slope* is a feature, worthy of consideration. It should have the same value in the short wave bands as in the medium and long wave band.

As a fourth quantity, we have *feed-back*. This may be expressed as an impedance between output—and input electrode *in* the tube, i.e., between input grid and anode. At the medium and long wave bands this impedance is a capacitance : the grid-anode capacitance, and is kept as low as possible, actually some thousandths of one $\mu\mu$F with H.F. pentodes. The feed-back impedance has to do with the upper amplification limit. It causes a certain part of the output voltage to react on the input and, if phase relations are favourable, may cause oscillation.

Thus, the four required constants are :

input impedance,
output impedance,
slope,
feed-back impedance.

II. Principles of Measurement

Attempts have been made to measure tube impedance values by replacing the valve by a resistance and a capacitance in parallel. However, in the short wave region, especially above 20 Mc/s, the values of such resistances may differ appreciably from the D.C. value and thus cause trouble in the interpretation of measured results. In all the measurements, referred to here, a tuned circuit was used, over which a diode voltmeter measures the alternating voltage. This voltmeter is dealt with in Section III. Several oscillators were built, covering the waverange between 200 and 1 m. wavelength. The oscillator is coupled with this circuit in such a way, that practically no variation of generated voltage or frequency occurs by detuning the circuit. The circuit condenser has about 20 or 10 (above 60 Mc/s) $\mu\mu$F maximum capacity. A calibration curve, taken at low frequencies, gives the $\mu\mu$F value (e.g. 0·15 $\mu\mu$F) corresponding to one scale division. The scales may be read to 1/10 division. Let the voltage over the circuit in the tuned position be e. Let ΔC be the detuning of the circuit condenser (Farad), starting from this position, necessary to bring the circuit voltage down to $e/\sqrt{2}$. Then the resistance R, equivalent to the circuit in the tuned position is $R = 1/\omega\,\Delta C$ (ohm), where $\omega = 2\pi$ times the frequency in cycles, corresponding to the tuning position of the circuit. Obviously,

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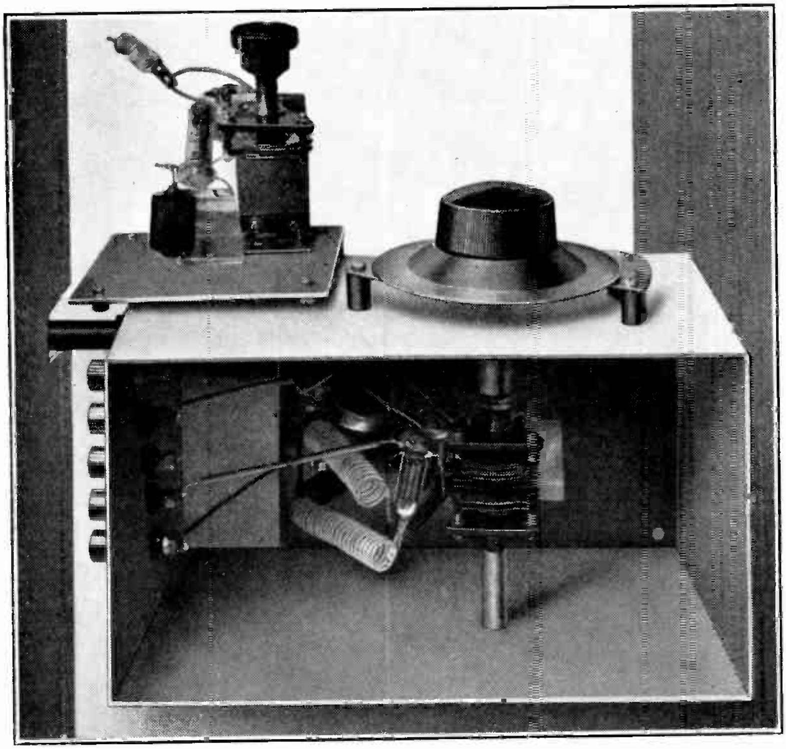
* MS accepted by the Editor, March, 1937.

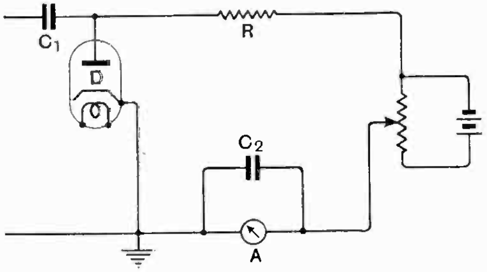
by measuring the circuit impedance first with the desired valve impedance parallel to it and then without the valve, the equivalent parallel resistance and capacitance of the valve impedance are known.

In order, that this method of measuring the impedance of a tuned circuit may yield correct results, the transmitter output must have one constant frequency. Often, in the region of 5 to 300 Mc/s, parasitic oscillations occur, resulting in the generation of a multitude of frequencies close together, or a frequency band, or both. This was controlled by the use of a back-coupled short wave receiver, which went up to 30 Mc/s. By tuning this receiver to the transmitter, one sharp whistling note is heard, if everything is correct. Often, a series of whistling notes, close together on the receiver tuning scale or a hiss are observed, indicating an undesirable state of oscillation in the transmitter. Several transmitters were used, each covering parts of the 1·5 to 300 Mc/s band. The Hartley scheme proved satisfactory throughout and careful adjustment of the coupling and the leakage resistance of the oscillator always led to the desired single frequency oscillation. At frequencies above 30 Mc/s, harmonics of the aforesaid receiver were made to give whistling notes with the transmitter frequency in order to check the state of oscillation. Above 30 Mc/s button tubes were used in the oscillators, the coils becoming smaller and smaller. Two transmitters are shown in Fig. 1. Frequency drift proved to be of no consequence in our measurements.



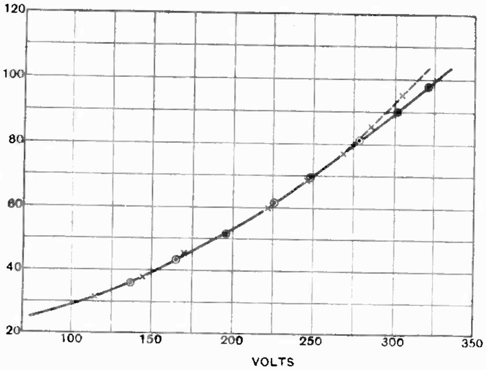
(*Left*) Fig. 1.—*Photo of two short wave transmitters. Upper transmitter* 1–2 *m wavelength ; Lower transmitter* 2–4 *m wavelength.*

(*Below*) Fig. 2.—*Connections of diode voltmeter. D, diode of acorn type* (0·1 *mm space between cathode and anode*) ; C_1, *condenser about* 2,000 $\mu\mu F$ (*mica*) ; *R, resistance* 0·2 $M\Omega$; *A, microammeter* (1 *division* = 0·01 *microamp, scale has* 100 *divisions*) ; C_2, *block condenser* 2,000 $\mu\mu F$ (*mica*).



III. Diode Voltmeter

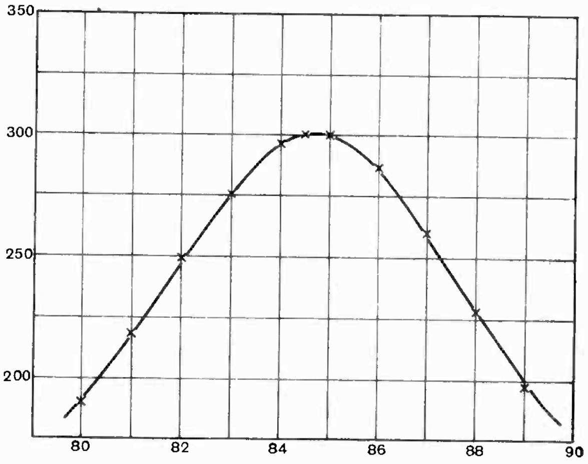
The connections of the diode voltmeter are shown in Fig. 2. Actual wiring is kept as short as possible. A button diode (1/10 mm distance between cathode and anode) is used. It can be predicted theoretically, that detection of such a diode will be practically the same at say 60 Mc/s as at 500 c/s. The voltmeter calibration curve was taken at the latter frequency. Several measurements (some of which were published, see *E.N.T.*, vol. 13, 1936, p. 260) indicate that this theoretical prediction holds good up to about 60 Mc/s.



(*Above*) Fig. 3.—*Relative calibration curves of diode voltmeter. Vertical : microamp. diode current ; horizontal : relative value of alternating volts on diode voltmeter. Crosses correspond to 1·26 m wavelength, circles to 5·0 m. Curves can be made to coincide, except at higher voltages, which correspond to rather high currents through the thermojunction, used to obtain these relative check curves.*

(*Right*) Fig. 4.—*Resonance curve at 1·26 m wavelength. Vertical scale : relative value of alternating volts across the tuned circuit ; horizontal scale : divisions of condenser scale. Points measured, curve calculated.*

Above 60 Mc/s, however, owing to transit time effects, even in a button diode deviations from the low frequency check curve occur. Now, for the course of measurements, explained in Section II, it is not necessary, that the voltmeter indicates the absolute value of the alternating voltage across the circuit. It will be sufficient to have a relative volt indication, such that the voltmeter readings have all to be multiplied by a common factor in order to get the true volts. This common factor, however, need not be known and may be a different one for every transmitter frequency used in the measurements. In order to get such a relative check curve of the diode voltmeter at any frequency under consideration, a simple method was applied. This method starts from the following assumption on thermo-electric couples. Take the D.C. calibration curve. Use this curve at any frequency. The heater current values will give the true alternating currents if multiplied by a factor, depending on the frequency only. A discussion of the action of thermo-electric-junctions at different frequencies leads to the conclusion, that this assumption will only be violated for alternating currents of too great values. A thermo-electric couple, the D.C. calibration-curve of which is known, is coupled with the coils of the short-wave transmitter. At the same time this transmitter is coupled to the tuned circuit with diode voltmeter. Then the strength of the transmitter is varied (e.g. by varying the D.C. potentials). Taking the ratio of the voltmeter readings equal to the ratio of the direct currents through the thermo-junction, which correspond to the measured thermo-tensions at the frequency under consideration, a relative calibration curve of the diode voltmeter at any frequency is obtained. This procedure was successful up to 300 Mc/s, but will very probably apply even at 3,000 Mc/s.



In Fig. 3 two relative calibration curves of the diode voltmeter, obtained by this method, are shown. They may be made to coincide, except at high current values. The latter range is not used in the measurements. This is evidence of the truth of the underlying assumption. Fig. 4 shows a resonance curve taken with the diode voltmeter at 1·26 m wavelength. The exact coincidence with the calculated curve is further evidence for the truth of said assumption.

IV. Shielding and Wiring

It was found that already at 30 Mc/s elaborate precautions were necessary, to prevent spurious effects, such as voltages being induced in an uncontrolled way on parts of the apparatus and especially on the tuned circuit. The finally adopted type of shielding consists of a number of 1 mm iron plate boxes with closely fitting covers. These boxes are interconnected by copper tube, 10 mm outside diameter, closely fitted to the boxes. One box contains the transmitter, a second one the transmitter batteries. The tension supply wires run through the copper tube interconnecting these boxes. A simple filter circuit, consisting of small coils and of condensers, prevents the generated voltage from reaching the batteries. The transmitter box is connected to the measuring box by a tube, which serves as outer lead of a concentric line, coupled to the transmitter circuit at one side and to the tuned circuit of the measuring box at the other side. In the tube an insulated wire serves as inner lead of the line. The measuring box is built in three different ways for the purposes of measuring input impedance, output impedance and retroaction impedance. Each box contains several compartments completely screened from each other. The batteries for the valves, which are measured in one of the compartments of each measuring box, are contained in separate battery-boxes, connected with the measuring boxes by means of copper tubes, as with the transmitter. The measuring instrument, being a microammeter (1 scale division corresponds to 0·01 μA) is contained in a separate box, connected to the measuring box (diode voltmeter compartment) by a copper tube. The reading slit of the instrument box is covered with copper gauze, in order to obtain most perfect screening. The complete apparatus for measuring input impedance of valves up to 300 Mc/s is shown in Fig. 5. The other two sets (for output impedance and for retroaction impedance) are rather similar in general appearance. Fig. 5 also shows a Lecher-wire system, which is used for determining wave lengths.

Fig. 6 shows the wiring scheme of the arrangement for measuring the anode impedance of valves. The separate compartments, into which the measuring box is subdivided are indicated by dotted lines. The alternating transmitter voltage is first connected to the tuned circuit and then to the tuned circuit in parallel to the valve to be measured. The values of R_1 and C_2 are chosen such, that the diode voltmeter D_1 indicates a constant voltage, whether the valve is connected to the tuned circuit or not.

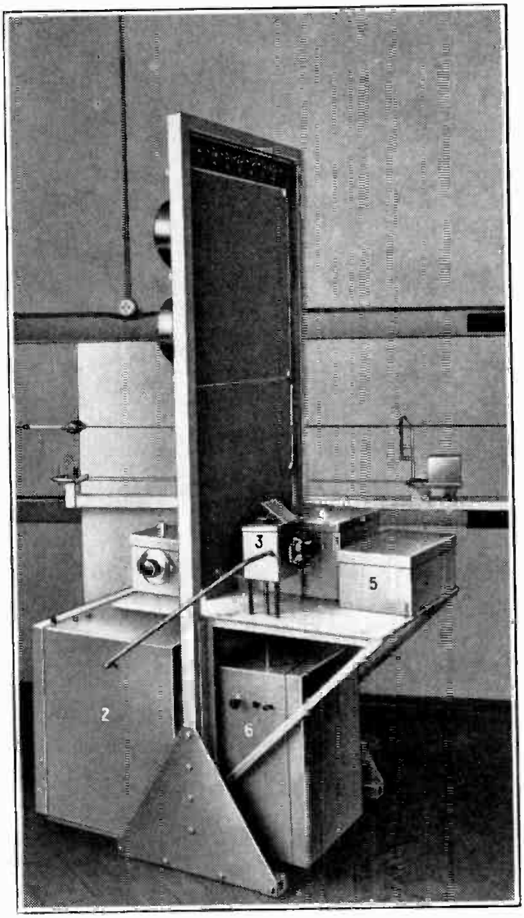
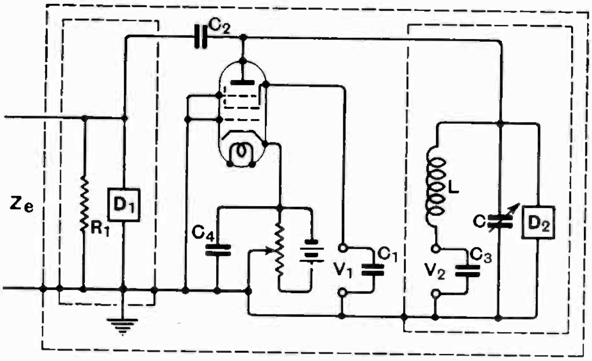


Fig. 5.—*View of complete apparatus for measuring input impedances.* 1, *transmitter box;* 2, *transmitter battery box;* 3, *measuring box of Fig. 7 for determining input impedance of acorn valves;* 4, *diode voltmeter batteries;* 5, *microammeter box;* 6, *battery box for valve to be measured.*

Using this same arrangement, with small obvious changes, the slope of valves was measured up to about 60 Mc/s. The absolute value of the slope was equal to the static value within a few per cents (error of the measuring results) up to this frequency. No material change of this value is expected up to 300 Mc/s.

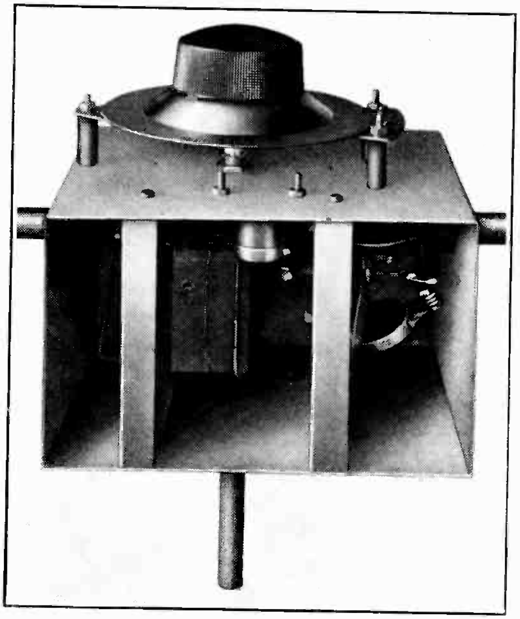


(Left) Fig. 6.—*Wiring of measuring arrangement for anode impedances. R_1, resistance* 1,000 *ohms ; Z_e, to transmitter ; D_1, and D_2, diode voltmeters of Fig.* 2 *; C_1,* 20,000 *$\mu\mu F$; C_2,* 0·1 *$\mu\mu F$; C_3,* 20,000 *$\mu\mu F$; C_4,* 20,000 *$\mu\mu F$; C, variable condenser max.* 15 *$\mu\mu F$; V_1, tension of screen grid ; V_2, tension of anode.*

A separate measuring box was used for measuring the grid input impedance of valves. The wiring scheme of this box need not, however, be explained by a new Fig. In Fig. 6 the anode has simply to be connected to earth by a 20,000 $\mu\mu$F condenser and the input grid to be disconnected from earth and connected to the condenser C_2, which is disconnected from the anode. Fig. 7 gives a view of the grid impedance box and its compartments, set up for measuring acorn valves. The left compartment contains the valve to be measured, the central compartment contains the circuit (coil in small copper cylinder) and the coupling (two parallel ends of wires) of the circuit to the transmitter line. The right compartment contains the diode voltmeter and related wiring. The box of Fig. 7 is mounted in Fig. 5 on the measuring table and panel.

Fig. 8 shows the wiring of the measuring box for determining feed-back impedance. The dotted lines again indicate the screened compartments of the measuring box. The alternating transmitter voltage is connected to the valve anode, which is connected to earth through a resistance of 500 ohms. This transmitter voltage could be varied between 3 and 30 volts (effective value) during the different measurements. A tuned circuit is connected to the input grid of the valve. The ratio of the voltage across this circuit to the anode alternating voltage is measured. It may be proved, that this ratio is equal to the absolute value of the anode-grid impedance divided by the tuned impedance of the grid circuit. Conditions for this equality are : The grid circuit must be tuned to maximum voltage across this circuit and the anode alternating voltage may not vary during this tuning operation.

(Below) Fig. 7.—*View of box for measuring grid impedances of acorn pentodes.*



V. Grid Impedance Values of some Valves

In Table I on the next page some measured values of grid impedances for different valves are brought together.

In the first column of the table the valve types AF3 and AF7 are : H.F. pentodes (Philips) with P — base (side prongs), AF3 being of the variable and AF7 of the fixed bias type. The other valves are also H.F. pentodes (Mullard), VP4B being of the

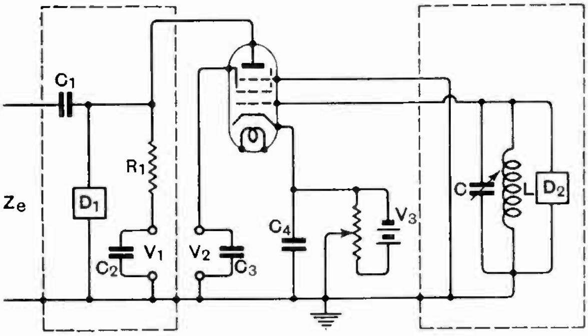


Fig. 8.—*Wiring of measuring arrangement for determining feed-back impedance ; Z_e, transmitter leads ; D_1, and D_2, diode voltmeter of Fig. 2 ; C_1, C_2, C_3, and C_4, 20,000 $\mu\mu F$ each ; R_1, 500 ohms ; V_1, tension of anode ; V_2, tension of screen grid ; V_3, tension 20 Volts max. ; C, variable condenser of 15$\mu\mu F$ max. ; L, self-inductance tuned with C to transmitter frequency.*

variable and the other valves of the fixed bias type. *R* cold means the input grid parallel resistance with unheated valve, whereas *R* biased is related to the valve under ordinary heater, anode and screen grid tensions, but with a bias tension on the input grid, which corresponds to practically zero anode current. *R* hot corresponds to normal slope conditions, given by the valve-makers, this slope being about 2 mA/V for the first four valves and about half this value for the acorn (button) type. The capacitances in the last two columns are $\mu\mu$F values and these are practically independent of wave-length. The value *R* active is given by 1/R active = 1/R hot − 1/R biased. This corresponds to the impedance part, determined by the action of the valve. Finite electron transit time causes a very marked decrease of *R* active at short

TABLE I.

Valve.	Wave-length, m.	*R* (M*Ω*).				*C* ($\mu\mu$F.).	
		Cold.	Biased.	Hot.	Active.	Cold.	Hot.
AF3	230.0	3.9	4.7	3.3	~~1.2~~ 12.	6.1	7.0
	62.5	2.3	—	1.1	1.4		
	39.5	1.6	2.6	0.38	0.45		
	26.0	0.86	1.8	0.17	0.19		
	21.2	0.74	1.5	0.108	0.116		
	16.2	0.50	0.74	0.062	0.067		
	12.4	0.40	0.54	0.036	0.039		
	8.6	—	—	0.015	—		
	5.6	0.19	0.21	0.0097	0.0102		
AF7	230.0	2.9	6.0	2.1	3.3	6.6	8.1
	62.5	2.2	6.2	0.79	0.92		
	39.5	1.5	2.7	0.26	0.29		
	26.0	1.0	2.3	0.11	0.12		
	21.2	0.69	1.4	0.070	0.074		
	16.2	0.51	0.86	0.039	0.041		
	12.4	0.35	0.84	0.023	0.024		
	8.6	0.15	0.17	0.011	0.012		
	5.6	0.11	0.12	0.0045	0.0046		
VP4B	19.6	0.8	1.3	0.090	0.096	5.9	7.1
	9.8	0.38	0.25	0.021	0.023		
SP4B	19.6	0.60	0.90	0.050	0.053	6.5	8.4
	9.8	0.28	0.31	0.011	0.011		
Acorn Pentode . .	8.0	1.1	0.9	0.12	0.14	3.25	3.65
	5.0	0.70	0.50	0.044	0.049		
	3.28	0.36	0.27	0.021	0.023		
	2.00	0.100	0.068	0.0068	0.0077		
	1.26	0.041	0.026	0.0025	0.0028		

wavelengths. The decrease of the other R-values must be ascribed to dielectric and other losses in the valve constructions.

The values R active for the acorn pentode are shown in Fig. 9. These values are almost exactly inversely proportional to the square of the frequency.

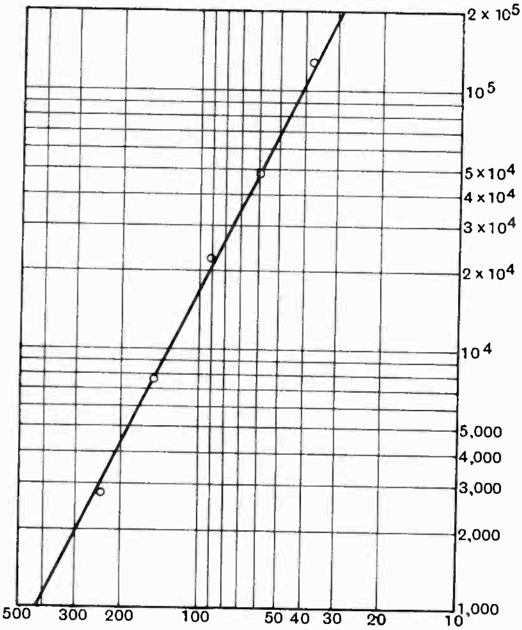


Fig. 9.—*Active grid parallel resistance of acorn pentodes (circles). Vertical : resistance ohms ; horizontal : frequency Mc/s.*

The above values correspond to valves, selected so as to be representatives of each type. Individual valves of each type may, however, show R-values, differing as much as 20 per cent. from the above quoted, owing to small deviations during the manufacturing processes.

VI. Anode Impedance Values of some Valves

Table II shows some measured values.

The valves were measured under normal operating conditions given by the valve-makers, bias being such that the slope of the first two valves was about 2 mA/V, and of the acorn valve about half this value, whereas the anode currents of the VP4B and SP4B were adjusted to 8 and 3 mA respectively. The meanings of the suscripts " cold " " biased," etc., are the same as those in Table I. The capacitances of any one valve are equal in all the conditions and hence are not quoted in the table. Generally, anode resistance is much greater than grid resistance for any of the valves considered. The decrease of anode resistance at short wavelengths is not due to electron transit times. It is caused by losses in the valve constructions and by coupling effects between the leads and electrodes of the valves.

VII. Feed-back Impedances of some Valves

The measured absolute value of the feed-back impedance Z_r in ohms is given for some valves in Table III.

The difference between the hot and cold values could be explained by taking into account the altered cathode-heater-capacity under these circumstances and the properties of the measuring set, especially the condensers C_2, C_3 and C_4 of Fig. 8. This being of no further interest for the consideration of valve properties, only cold values were measured for the valves VP4B and acorn pentode.

The impedance between anode and grid in a valve can be represented by a capacitance at the longer wavelengths. Continuing this in the short wave region, the

TABLE II.

Valve.	Wave-length. m.	R (MΩ).			
		Cold.	Biased.	Hot.	Active.
AF3	62.5	0.75	0.67	0.43	1.2
	33·5	0.52	0.47	0.34	1.3
	20.4	0.35	0.29	0.19	0.54
	12.1	0.20	0.18	0.11	0.26
	8.0	0.11	0.097	0.056	0.13
	5·05	—	0.038	0.022	0.054
AF7	62.5	1.12	1.12	0.68	1.7
	33·5	0.75	0.73	0.50	1.6
	20.4	0.49	0.45	0.25	0.58
	12.1	0.24	0.22	0.11	0.24
	8.0	0.081	0.078	0.045	0.11
	5·05	0.046	0.041	0.024	0.058
VP4B	20.6	0.26	—	0.18	—
	10.3	0.114	—	0.072	—
	4·95	0.040	—	0.025	—
SP4B	20.6	0.25	—	0.17	—
	10.3	0.123	—	0.072	—
	4·95	0.040	—	0.023	—
Acorn Pentode	10.0	1.0	—	—	—
	5·0	0.50	—	—	—

TABLE III.

Valve.	Wave-length, m.	Z_r (Ohms).	
		Hot.	Cold.
AF3 . .	58.5	11.0 . 10^6	12.0 . 10^6
	24.6	5.4 . 10^6	7.9 . 10^6
	19.8	2.6 . 10^6	3.6 . 10^6
	12.0	0.34 . 10^6	0.46 . 10^6
	8.0	86.0 . 10^3	110.0 . 10^3
	5.2	25.0 . 10^3	31.0 . 10^3
AF7 . .	58.5	12.4 . 10^6	12.9 . 10^6
	8.0	81.0 . 10^3	124.0 . 10^3
VP4B . .	60.0	—	14.0 . 10^6
	10.0	—	0.30 . 10^6
	5.5	—	0.048 . 10^6
Acorn Pentode . .	40.0	—	2.7 . 10^6
	20.0	—	1.4 . 10^6
	10.0	—	0.72 . 10^6
	5.0	—	0.42 . 10^6

anode-grid-capacitance is found to alter its value as a function of wavelength. Thus, for the valve AF3 we have for this cold capacitance in $\mu\mu$F :

$$C = 0.0031 - 0.0075 \cdot 10^{-16} \cdot (2\pi f)^2$$

where f is the frequency in c/s. For the VP4B the equation is

$$C = 0.0024 - 0.0059 \cdot 10^{-16}(2\pi f)^2$$

These equations represent the measured values of feed-back impedance quite accurately. The anode-grid-capacity decreases with increasing frequency till it is zero at a certain critical frequency, then becomes negative and increases again very fast. The acorn pentode is again by far the best one of all the valves considered.

VIII. Discussion of the Results

It is first proposed, to derive generally the frequency dependence of the impedances dealt with above on theoretical grounds. Any of the valve impedances may be represented by a resistance in parallel with a capacitance, such that the admittances are :

$$A = \frac{1}{R} + j\omega C, \text{ where } \omega = 2\pi f \text{ and } j = +\sqrt{-1}.$$

Now, suppose, that anywhere inside the valve, e.g. in one of the leads, an additional impedance is inserted. How does the admittance A vary as a result of this insertion. The frequency ω enters into all the formulas only in the combination $j\omega$. Thus, developing the altered admittance A^1 in a Taylor series, we get

$$A^1 = A + a_0 + a_1 j\omega + a_2(j\omega)^2 + a_3 (j\omega)^3$$

from this, we may deduce the variations of $1/R$ and of C as a function of ω :

As the only imaginary values result from $j\omega$, the coefficients a_0, a_1, a_2, etc., must be real quantities.

$$\frac{1}{R^1} = \frac{1}{R} + a_0 - a_2\omega^2 \text{ and } C^1 = C + a_1 - a_3\omega^2 + \ldots$$

In words : The variations of the reciprocal parallel resistance and of the capacitance, representing any valve admittance by the insertion of any additional impedances in the valve (e.g. in the leads) are even functions of the frequency ω, i.e. the first frequency dependent term must be proportional to ω^2. This rule holds also, if no additional impedances have been inserted purposely. At higher frequencies, some impedances inside the valves (e.g. the self—and mutual inductances of the leads) become more and more important and cause variations of the measured valve impedances, such as input impedance, output impedance and retroaction impedance. The equivalent resistances and capacitances of these variations must contain the frequency ω in the forms ω^2, ω^4, ω^6, etc. but no terms ω, ω^3, etc.

At high frequencies, the transit times of electrons become important factors, which manifest themselves in the valve impedances. Here again the frequency enters into the formulas only in the combination $j\omega$. Hence, the above rule may be deduced in exactly the same way, leading to the same result as regards the variation of valve impedances in the short wave region.

On the contrary, dielectric losses in the valve insulating parts may be frequency dependent in such a way, that the above rule of the frequency dependence of the valve impedances does not apply, if such losses are a relevant cause of their variations. Thus, the *cold* valve impedances are not necessarily even functions of ω. But the active parts of the valve impedances must be.

This is completely confirmed by the measured active impedances of the Tables I and II. The values of the active resistances in these tables with increasing frequencies are functions of ω^2, as they must be theoretically. Considering Table III, the fact, that the retroaction impedance can be represented by a capacity with great accuracy, indicates, that valve dielectric losses are irrelevant for this impedance. Hence the above rule can be applied and it may be predicted theoretically, that the feed-back capacity has a part independent of frequency and a part proportional to the square of the frequency. This latter part turns out to have a negative coefficient in the valves measured.

As to the physical causes of the decrease of valve impedances at increasing frequency, in the case of anode impedance and retroaction, the coupling between different electrodes inside the valves accounts fully and even, as shown by calculations, numerically for the variations of active anode impedance and of feed-back. The decrease of input impedance, however, is for the greater part due to electron transit time between cathode and grid.

IX. Voltage Amplification at very short Wave Lengths

The quality of tuned circuits in the short-wave region is determined: first by losses of coils and condensers, secondly by the tolerances of valve input and output capacitances, thirdly by the variations of the valve input capacitances, when applying a variable bias tension for controlling the amplification. The second point arises from the consideration, that often no additional trimming of the tuned circuits is desired when replacing one valve by another of the same type. With most modern H.F. pentodes, acorn tubes excepted, the tolerances of said capacitances are about $\pm 0{\cdot}6$ $\mu\mu$F. The capacitance variations mentioned in point three are about 1 $\mu\mu$F at most, but for many applications also will not exceed 0·6 or 0·7 $\mu\mu$F. Now assume that a tuned circuit should not be detuned more by a capacitance variation of 0·6 than corresponds to a drop on the resonance curve to $1/\sqrt{2}$ of the maximum value. What is, in this case, the maximum circuit impedance R at any wavelength? Using the formula mentioned in Section II, $R = 1/\omega \Delta C$, where $\Delta C = 0{\cdot}6$ $\mu\mu$F and $\omega = 2\pi f$ (f frequency in c/s). As $f = 3 \,.\, 10^8/\lambda$ (λ wavelength in meters) this yields: R (ohms) $= \lambda\ (m) \times /2\pi \,.\, 3 \,.\, 10^8 \,.\, 0{\cdot}6 \,.\, 10^{-12} = \lambda\ (m)/1{\cdot}1 \,.\, 10^{-3}$. Within a small error this result corresponds to the rule: make the tuned circuit impedance at any wavelength equal to as many times 1,000 ohms as the wavelength in meters. The losses are such that circuits of this type can be easily made. Thus, without special precautions, circuit impedances of 26,000, 17,000, 9,000, 5,000 and 2,300 ohms were obtained at 8, 5, 3·3, 2 and 1·26 meters wavelength.

The output impedance of valves is shown in Tables I and II to be always much better than the input impedance. The input impedance of the valves AF3 and VP4B in Table I is such, that even at 5 m wavelength, using circuits of the above type, amplification factors of 6 to 8 times per stage are possible. With the acorn pentode, even at 1 m wavelength an amplification of 1·5 could be obtained. The valves AF7 and SP4B will give only about 2 to 4 times amplification at 5 m wavelength.

Considering feed-back impedance, the condition that a H.F. stage will not oscillate is $SR^2/Z_r < 1$, where S is the slope (A/V), R the tuned circuit impedance (ohms) and Z_r the absolute value of the feed-back impedance (ohms) as given in Table III. Taking the valve VP4B we have $S = 0{\cdot}002$, $R = 5{,}000$ ohms, $Z_r = 4{,}800$ ohms at 5·5 m and hence $SR^2/Z_r = 1{\cdot}04$. At this wavelength, though it is not certain that oscillation of a H.F. stage using this valve will occur, for safety, R should be lowered, e.g. to 4,000 ohms or S lowered by applying bias tension on the input grid.

The author takes pleasure in acknowledging the collaboration of Dr. A. van der Ziel in obtaining the results dealt with above.

Summary

According to Section I the four fundamental constants of H.F valves are: input impedance, output impedance, slope and feed-back impedance. Section II deals with the measurement of these constants by the

use of a resonance circuit and a diode voltmeter across this circuit. Some remarks are made as regards transmitters up to 300 Mc/s. Section III gives a description of the procedure for obtaining calibration curves of the diode voltmeter up to 300 Mc/s. The shielding and wiring of the different measuring arrangements are fully described in Section IV. Section V contains values of input impedance for the valves AF3, AF7 (Philips) SP4B, VP4B (Mullard) and for the acorn pentode (Mullard) up to 300 Mc/s. In Section VI values of output impedance for these valves are given up to 60 Mc/s. Section VII contains feed-back impedances of said valve types up to 60 Mc/s. In Section VIII a discussion of the results is given, wherein it is deduced, theoretically, that the reciprocal resistance and the capacitance, equivalent to any of the measured impedances so long as the *active* parts are considered, must be functions of the *square* of the frequency. This is confirmed by the Tables I, II and III. The physical causes for the decrease of active impedances at higher frequencies are dealt with briefly. The last Section (IX) gives the recommended circuit qualities on short wavelengths and, using these circuits, shows, that H.F. amplification at 5 m is possible using the valves AF3 or VP4B, giving amplifications of 5 and more.

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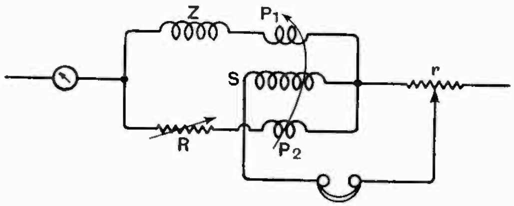
Correspondence

Letters of technical interest are always welcome. In publishing such communications the Editors do not necessarily endorse any technical or general statements which they may contain

Bridge for Direct Impedance Measurement

To the Editor, The Wireless Engineer.

SIR,—Your Editorial under the above heading in the May issue tempts me to draw your attention to a simple and ingenious bridge invented by Mr. W. H. Grinsted and used in the shops and laboratories of Messrs. Siemens Bros. since 1920. It was designed for the purpose of measuring, quickly and conveniently and frequently by semi-skilled operators, the modulus and argument of pieces of telephone apparatus such as receivers, "induction coils," feeding-bridges, etc., at one frequency (796 c/s.).



The value of the impedance is rarely less than 100 Ω or more than 20,000 Ω and an accuracy of 1 or 2 % is usually adequate.

Z is the impedance to be measured.

R is a N.I. resistance box.

r is a N.I. sliding-resistance, which may be calibrated in degrees of argument for any one frequency.

P_1 and P_2 are the equal primary windings of a mutual inductance, the D.C. resistance and stray capacitances of which are kept as low as possible.

S is the secondary winding of this mutual inductance.

On balance, R gives the modulus and r the argument of Z.

The theory of this bridge is so simple that a further description is scarcely warranted.

Messrs. Tinsley have been manufacturing it in commercial form for some years.

G. W. SUTTON.

London, S.E.18. Siemens Brothers & Co. Ltd.

Frequency Changers in All-Wave Receivers

To the Editor, The Wireless Engineer.

SIR,—Dr. Strutt in his article "Frequency Changers in All-Wave Receivers," published in the April, 1937, issue of *The Wireless Engineer*, has pointed out clearly the defects of both of the two major types of frequency converters when used in receivers which must cover both low and high frequencies. His discussion, however, seems to point to an improved Octode (*inner*-grid injection of oscillator voltage) as approaching the ideal somewhat more closely than the type of mixer tube in which the oscillator voltage is applied to an *outer* grid. A similar analysis of the two types made in this laboratory has led to an opposite result. In the first place, it is believed to be too difficult and too inconvenient to neutralize properly, over a wide range of conditions, the "electron coupling" found in the former type of mixer. A second factor leading to a reversal of Dr. Strutt's conclusion is that it has been found possible to eliminate the major defects of the latter type.

The early experiments made by W. A. Harris of this Company also indicated, as Dr. Strutt has described, that this space-charge coupling was largely a one-way negative capacitance which could be neutralized by a small positive capacitance connected from oscillator to signal grid. Subsequently, however, an investigation of the signal grid input impedance as a function of oscillator-grid voltage by the writer indicated that a transit time effect was present which changed markedly the conductance of this grid. At high frequencies (i.e., 20 to 30 megacycles) the data showed that this conductance change was almost as important as the capacitance change in contributing to an induced voltage of oscillator frequency on the control grid circuit. Calculation indicated that neutralization could be effected by a combination of a resistance and a neutralizing capacitance (preferably in series) connected from oscillator to signal grids: this was verified by trial on an RCA 6A8 Pentagrid converter with a separate oscillator applied to the first grid.

At 20 megacycles, with an 8,000-ohm signal-grid circuit tuned to give maximum, fundamental oscillator frequency, induced voltage, the following data were obtained on an RCA 6A8 tube:

Neutralization.	Applied Oscillator Volts.	Induced Signal-Grid Volts.	Ratio.
None	1.5	3.60	2.40
Capacitance only (approx. 2 $\mu\mu$F) ..	6.0	3.30	0.55
Capacitance and series resistance (approx. 2 $\mu\mu$F and 455 ohms)	6.0	0	0

The tests indicated that perfect neutralization was possible at any one frequency, but was so critical in adjustment as to remain only approximate over a band of frequencies. The neutralization values varied also with applied oscillator voltage; for example, an increase in oscillator voltage to 12.0 volts in the last case of the table above induced 2.0 volts on the signal grid. A slight decrease in the capacitance and an increase in the resistance to about 500 ohms brought the induced voltage back to zero. This behaviour had already been qualitatively predicted by inspection of the signal-grid admittance data. From the point of view of a receiver manufacturer attempting to use reasonably complete neutralization in large-scale production, the critical adjustment necessary is most discouraging.

One of the advantages of the Octode, or inner-grid injection type of mixer, as pointed out by Dr. Strutt, is the high signal-grid input resistance. If it is necessary to neutralize the "electron coupling" by the above means (i.e., including a series resistance) it is found that the advantage is lost because of the increased losses due to the neutralizing resistor. Under these conditions such a mixer is usually inferior to the *outer*-grid injection type, if the same conversion conductance is assumed. If neutralization is not resorted to, operation at large ratios of signal frequency to I.F. is not practicable.

The work done here on the *outer*-grid injection type of mixer has shown that the low input resistance and the high signal-grid current at high frequencies are caused by the electrons returned by the oscillator grid to the signal-grid region. By the application of electron beam principles together with specially devised constructions it has been found possible to prevent the returned electrons from reaching the signal grid without in any way sacrificing the other desirable features of this type of mixer. The writer believes it unlikely that equivalent results can be achieved in the Pentagrid or Octode type of converter.

It appears as if the only remaining disadvantage of the *outer*-grid injection type mixer lies in the change of signal-grid capacitance with A.V.C. voltage. This difficulty is present to an equal degree in r-f amplifier tubes: its seriousness does not seem to be fully appreciated as yet.

E. W. Herold,
New Jersey, U.S.A. RCA Manufacturing
Company, Inc.

Radio-Électricité Générale.

By R. Mesny. Vol. 2. Pp. 441+XXI. Etienne Chiron, 40 rue de Seine, Paris 6. 60 fr.

This is the second volume of a work which is to be completed in three volumes. The first was entitled "Étude des Circuits et de la propagation," the present one is on "Fonctionnement des lampes—Étude des émetteur et des récepteur," and the third not yet published will deal with "Émission et réception dirigées." This second volume is conveniently divided into two separate books each of about 220 pages. Any one who is acquainted with French wireless literature knows that Professor Mesny writes in a clear style, giving evidence of the practised teacher of the subject. The material is well arranged, the data carefully explained, simplifying assumptions made where permissible, and ample references given to original papers. The book is very well illustrated with graphs and diagrams of connections.

The first thirteen chapters are devoted to valves, and their various applications as amplifiers, detectors, oscillation generators, etc. Chapter XIV deals with the various causes of noise in valves and valve circuits, Chapter XV with the coupling between the valve oscillation generator and the transmitting aerial, Chap. XVI with anti-fading aerials and synchronised stations, Chap. XVII with high-frequency insulators, Chap. XVIII with the design of masts, earth systems and counterpoises Chap. XIX with receiving aerial and the final chapter with aerials of the Beverage type.

The book would form a very good text-book for classes and we welcome it as a useful addition to the literature of the subject.

G. W. O. H.

A Thermionic Wattmeter*

By Raymond J. Wey, A.M.I.R.E.

SUMMARY.—The action of a multi-grid valve of the heptode type when used as a means of measuring power is examined theoretically, it being shown that the effect of curvature of the characteristics can be substantially eliminated by the method of phase reversal of grid voltage.

The effect of harmonics in the applied voltages is examined and it is concluded that although odd harmonics have no effect, even harmonics can cause errors. It is shown that the mean of two measurements made with opposite polarity of load current gives the true value.

These conclusions were verified experimentally, it being found that with the type of valve used in the tests an accuracy of about 1 to 2 per cent. could be obtained with sinusoidal input, provided the grid voltages were limited in value.

The effects of phase angle and harmonics were investigated and found to be substantially in accordance with the theoretical conclusions.

Finally, methods of deriving the necessary grid voltages from the load circuit are described.

1. Introduction

ALTHOUGH thermionic valves are extensively used for measurements of all kinds, and particularly of voltage, the measurement of power has received comparatively little attention. A thermionic wattmeter must necessarily be more complex than a thermionic voltmeter, since fundamentally it must measure the instantaneous product of two electrical quantities, the load voltage and current. Thermionic valves being substantially voltage operated devices, except at higher radio frequencies, it is necessary to produce a voltage proportional to the load current. This means that a resistance must be connected in series with the load, and the thermionic device must be capable of measuring the product of two voltages, *i.e.*, the load voltage and the voltage drop across this additional series resistance.

At the present time two methods of power measurement based on this principle are known. The first method, in which two triode valves are used in a special differential circuit, has been described by Dr. E. Mallet.[1] It may be regarded as an indirect method, in that the electron stream of each valve is modulated by one grid only, no direct multiplication of one voltage by another taking place in the valve. The second method, with which this article deals, may be termed a direct method, since a multiple-grid valve is used, in which the electron stream is modulated simultaneously by two grids in such a way that the resultant change of anode current is a function of the voltages applied to the two grids.

The heptode valve, commonly used for frequency changing in superheterodyne receivers, is a well-known type of multiple grid valve in which the electron stream is controlled by two independent grids. It is virtually a combined triode and tetrode with a common cathode and electron stream. Referring to Fig. 4, it will be seen that the stream of electrons, after emission from the cathode, is first modulated by the grid 1, normally the oscillator grid, after which it passes grid 2, which forms the oscillator anode. This latter grid is so dimensioned as to exercise practically no controlling influence over the electrons, the majority of which thus pass on to grid 3. This, with grid 5, forms a screen around grid 4, and, being maintained at a positive potential with respect to the cathode, must be supplied with current from the external circuit. Grid 4 is the control grid of the tetrode portion of the valve, and is normally supplied with the signal frequency input. The modulation of the electron stream at the oscillator frequency by grid 1 and then at the signal frequency by grid 4 gives rise to beat frequency components in the anode current.

The application of the heptode valve to the measurement of power followed some previous investigation by the author into the mechanism of frequency changing, described in a previous article in this

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* MS. accepted by the Editor, April, 1937.

[1] "A Valve Wattmeter," *I.E.E. Journal*, Sept., 1933, Vol. 73, p. 295.

Journal.[2] It was shown that the beat frequency component was proportional to the product of the alternating voltages at grids 1 and 4, or

$$I_B = g\frac{E_0 E_g}{2}(a + 2bP)$$

where I_B = max. value of beat frequency component of anode current.

E_0 = max. value of oscillator grid voltage.

E_g = max. value of control grid voltage.

The other terms in this equation are constants depending upon the valve characteristics and operating conditions and are explained in Section 2.

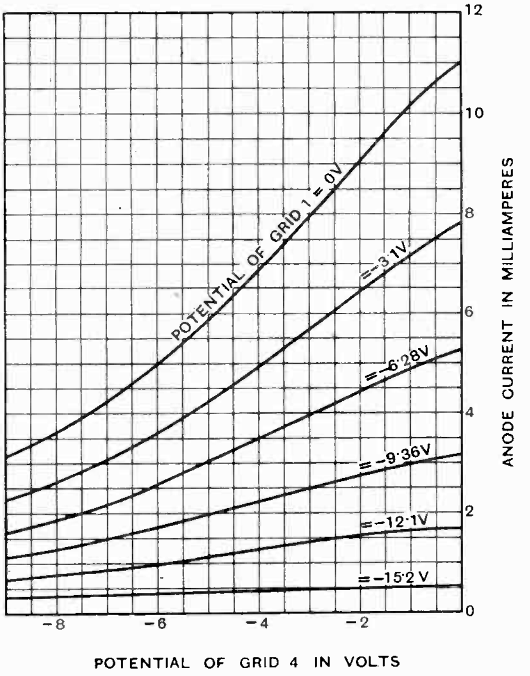

Fig. 1.

It was also shown that the two grid voltages of different frequency can be regarded as of the same frequency but of continuously varying phase, the maximum value of anode current occurring when the phase difference is zero, and the minimum value when the phase difference is at a maximum, *i.e.*, 180°. The difference between the maximum and minimum values of anode current is equal to the total swing of the beat frequency component. It is thus evident that the oscillator and control grids may be supplied with alternating voltages of the same frequency, and by changing the phase relationship of these voltages (*i.e.*, changing the polarity of one of them) the change in anode current of the valve will be proportional to the product of the two alternating voltages. The theory underlying this method will now be examined in detail.

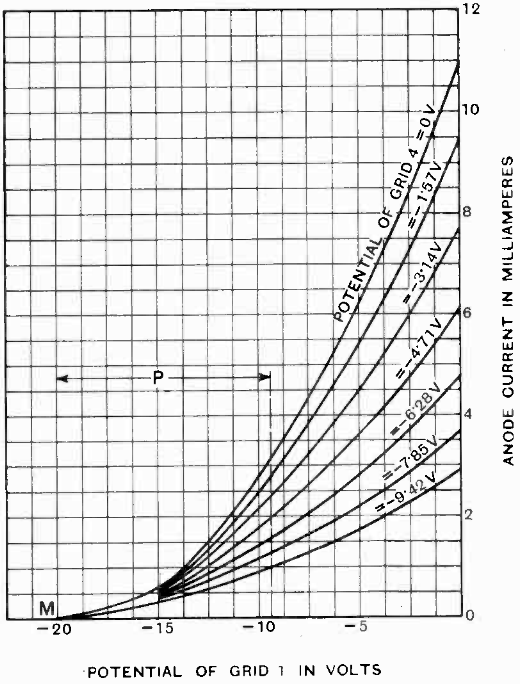

Fig. 2.

2. Theory of the Method

The static characteristics of the heptode valve used in these investigations are shown in Figs. 1 and 2. The valve was a 2A7 type, and the choice of suitable operating conditions was simplified by the previous work carried out on this type of valve. Referring to Figs. 1 and 3 it will be seen that the anode current-control grid voltage characteristics at a particular value of grid bias can be represented approximately by a series of divergent straight lines passing

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[2] "Heptode Frequency Changers," *W.E. and E.W.*, Dec., 1934, Vol. 11, p. 642.

through a common point N on the zero anode current abscissa. In the previous calculation of the beat frequency component this linear relationship was assumed to hold rigidly, since the grid input is usually small in frequency changing. In the present case, however, it was decided to include a second order term in order to determine what effect departure from linearity had on the accuracy of measurement. Fig. 2 shows the effect of oscillator grid voltage at various values of control grid voltage, and these characteristics can be represented with reasonable accuracy by the sum of the first and second powers of a series. The combined effect of the potentials of the oscillator grid and control grid, referred to hereafter as grids 1 and 4 respectively, on the anode current can thus be represented by the following equation :—

$$i_a = (aP + bP^2)\{g(Q + e_4) + he_4^2\} \quad .. \quad (1)$$

where

i_a = instantaneous anode current.

I = change of anode current.

P = bias of grid 1 measured from point M of zero anode current.

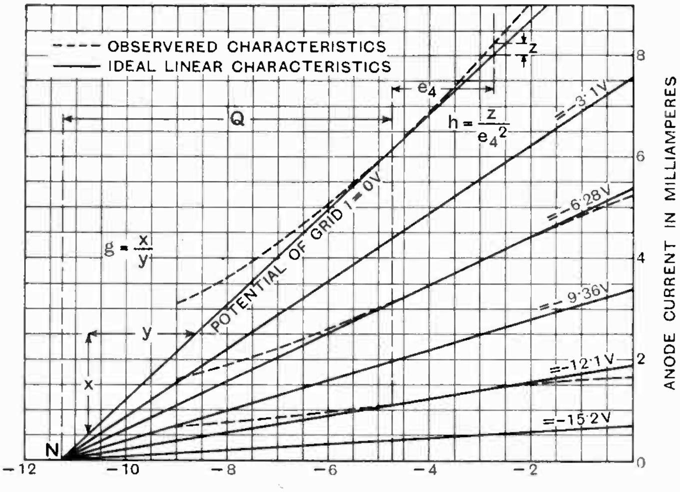

Fig. 3.

Q = bias of grid 4 measured from point N.

e_1 = instantaneous value of alternating voltage applied to grid 1.

e_4 = instantaneous value of alternating voltage applied to grid 4.

i_1 = instantaneous anode current when e_1 and e_4 are in phase.

i_2 = instantaneous anode current when e_1 and e_4 are in phase opposition.

g = mean mutual conductance of grid 4 at bias Q, zero grid 1 potential.

$\left.\begin{matrix} a \\ b \\ h \end{matrix}\right\}$ = constants derived from static characteristics.

When e_1 and e_4 are applied simultaneously, and in phase, to the respective grids,

$$\begin{aligned} i_1 &= \{a(P+e_1)+b(P+e_1)^2\}\{g(Q+e_4)+he_4^2\} \\ &= ag(PQ + Pe_4 + Qe_1 + e_1e_4) \\ &\quad + ah(Pe_4^2 + e_1e_4^2) \\ &\quad + bgQ(P^2 + 2Pe_1 + e_1^2) \\ &\quad + bg(P^2e_4 + 2Pe_1e_4 + e_1^2e_4) \\ &\quad + bh(P^2e_4^2 + 2Pe_1e_4^2 + e_1^2e_4^2) \end{aligned}$$

Now it is possible to change the phase of either e_1 or e_4 to obtain i_2; assuming at present that e_4 is reversed, it is found that $i_1 - i_2$, the difference in instantaneous anode currents in the two cases, contains terms in e_4, e_4e_1 and $e_4e_1^2$ only, and is given by

$$\begin{aligned} i_1 - i_2 &= 2ag(Pe_4 + e_1e_4) \\ &\quad + 2bg(P^2e_4 + 2Pe_1e_4 + e_1^2e_4) \end{aligned}$$

The anode current meter will indicate mean values, i.e.,

$$I = \frac{1}{2\pi}\int_{\theta=0}^{\theta=2\pi}(i_1 - i_2)\,d\theta.$$

Also, when e_1 and e_4 are alternating voltages the mean value of terms in e_1 or e_4 only is zero, hence

$$\begin{aligned} \int i_1 - i_2 &= \int 2ag\,e_1e_4 + 2bg\,e_1^2e_4 \\ &\quad + 4bgPe_1e_4 \\ &= 2g\int e_1e_4(a + 2bP) \\ &\quad + be_1^2e_4 \quad .. \quad (2) \end{aligned}$$

Thus it will be seen that the resultant change in mean anode current caused by reversing the polarity of e_4 is proportional to the product of e_1e_4 only when the second term is negligible compared with the first, since it involves the square of e_1. One condition giving zero value for the second terms is when e_1 and e_4 are sinusoidal voltages. In this case the change of anode current, derived from equation 2, is

$$I = \frac{g}{\pi}(a + 2bP)\int_{\theta=0}^{\theta=2\pi} e_1 e_4 \, d\theta$$
$$= g(a + 2bP)E_1 E_4 \cos p \quad .. \quad (3)$$

where $e_1 = E_1 \sin \theta$

$e_4 = E_4 \sin(\theta + p)$

Thus, when one of the voltages E_1 or E_4 is the voltage drop over the load whilst the other is the voltage drop over a series resistance, it will be apparent that I is proportional to the power in the load.

3. Effect of Harmonics

It will be evident from equation 2 that when harmonics are present in either or both of the applied grid voltages e_1 and e_4 an error will be caused, which is given by

$$\frac{b\int e_1{}^2 e_4}{(a + 2bP)\int e_1 e_4} \times 100\,\% \quad .. \quad (4)$$

Thus the error will depend both upon the valve characteristics and the waveform of the grid voltages, and therefore will generally be of indeterminate magnitude, since the waveform is seldom known with any accuracy. The evaluation of the above expression, which in any case would be somewhat tedious, is actually unnecessary, for a method will be described by which the error can be eliminated.

Theoretically, odd harmonics only should cause no errors, as $\int e_1{}^2 e_4$ is then zero, but even harmonics can cause serious errors which will be proportional to the magnitude of E_1, other factors remaining constant, since

$$\int e_1{}^2 e_4 \;\; p \;\; E_1{}^2 E_4$$
$$\int e_1 e_4 \;\; p \;\; E_1 E_4$$
$$\therefore \quad \frac{\int e_1{}^2 e_4}{\int e_1 e_4} \;\; p \;\; E_1$$

where E_1 and E_4 are the maximum values of e_1 and e_4 respectively. It should be noted that neither the magnitude of E_4 nor the curvature of the grid volts—anode current characteristic ($e_4 - i_a$) has any effect on accuracy, the curvature factor h being absent from equation 4.

If the equations given in Section 2 are reworked, assuming this time that e_1 be reversed in polarity instead of e_4, it is found that $i_1 - i_2$ now contains only terms in e_1, $e_1 e_4$ and $e_1 e_4{}^2$ and is given by

$$i_1 - i_2 = 2ag(Qe_1 + e_1 e_4) + 2ah\, e_1 e_4{}^2$$
$$+ 4bgP(Qe_1 + e_1 e_4) + 4bhPe_1 e_4{}^2$$

Upon integration, terms in e_1 or e_4 only become zero

$$\therefore \int i_1 - i_2 = 2\int ag\, e_1 e_4 + ah\, e_1 e_4{}^2$$
$$+ 2bgPe_1 e_4 + 2bhPe_1 e_4{}^2$$
$$= 2\int g(a + 2bP)e_1 e_4 + h(a + 2bP)e_1 e_4{}^2 \quad .. \quad .. \quad (5)$$

This result, as would be anticipated, is identical with the previous result, equation 2, when the second terms are zero. When even harmonics are present, the error due to the second term is of different value, however, and is given by

$$\frac{h\int e_1 e_4{}^2}{g\int e_1 e_4} \times 100\,\% \quad .. \quad .. \quad (6)$$

In this case the error is independent of the magnitude of E_1 and of the curvature of the $e_1 - i_a$ characteristic, since the factors a and b do not appear.

Summing up, it will be seen that the difference in mean anode current of a heptode valve having characteristics capable of being expressed by equation 1, obtained by reversing either of the applied grid voltages, is equal to

$$I = \frac{g}{\pi}(a + 2bP)\int_{\theta=0}^{\theta=2\pi} e_1 e_4 \, d\theta \quad .. \quad (7)$$

provided that no even harmonics are present. Furthermore, the effect of curvature of either of the characteristics $e_1 - i_a$ or $e_4 - i_a$ can be eliminated by reversing the voltage applied to that grid giving the curved characteristic.

4. Elimination of Error Due to Harmonics

If the expression for the error given in equation 4 be examined, it will be seen that when e_1 is reversed in polarity the numerator remains unchanged, whilst the denominator changes sign. The error has thus been changed in sign but not in magnitude. Thus it is evident that if two measurements are made, the first by noting the change in anode current when the voltage e_4 applied to grid 4 is reversed, and the second by changing the polarity of the voltage e_1 applied to grid 1 and repeating the measurement, two values will be obtained having equal and opposite errors, the mean of these being the true value.

Similarly, in the second case considered, in which the error is given by equation 6, this error can be eliminated by making two measurements, with e_4 reversed for the second determination.

Obviously, the validity of the above conclusions depends upon the assumption that the valve characteristics can be represented by equation 1. Since this only holds accurately over a limited range, errors are to be expected at large values of input voltages. It will be seen later that this effect is actually observed in practice.

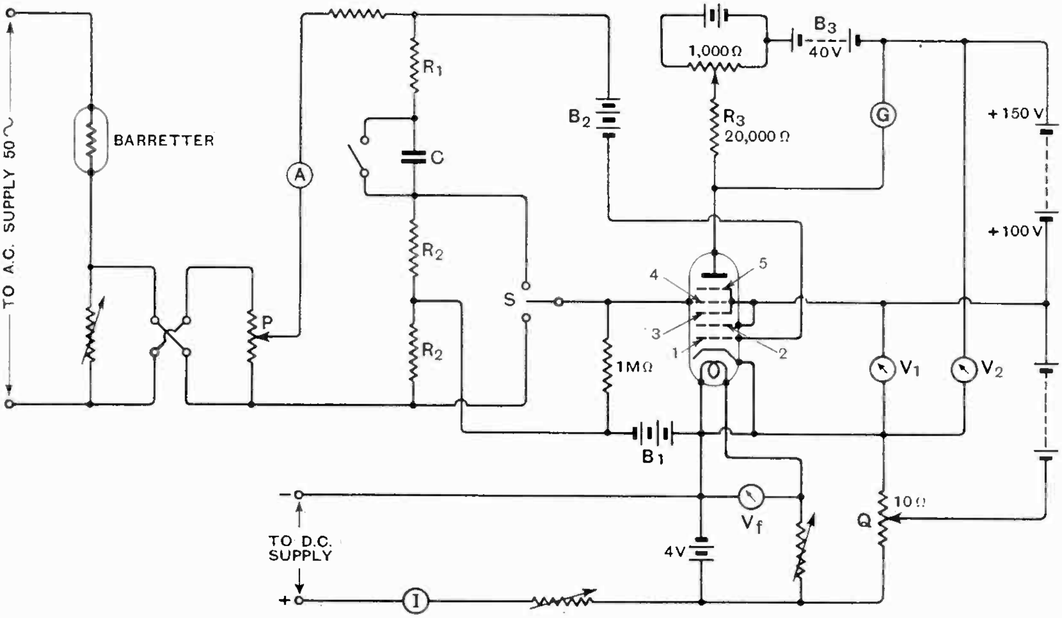

Fig. 4.

Before passing on to the experimental work verifying the conclusions reached above it is of interest to note that a method of power measurement has been described by J. R. Pierce[3], in which the measurement was made by noting the difference in steady anode current of a heptode valve caused by applying the alternating voltages to both grids simultaneously. It was shown that this difference in anode current was proportional to the power only if both grid characteristics were completely linear, since any curvature will result in a variation of mean anode current when one voltage only is applied, a condition which corresponds to zero power. It was also stated that no valve with completely linear characteristics could be found, the best giving a variation of anode current when e_4 was applied of 3% of that caused by the application of e_4 and e_1 simultaneously. Hence it was found necessary to balance out this change by using two similar heptode valves in the adjacent arms of a Wheatstone bridge. Grids 1 of both valves were connected together so that the variations of anode current due to the application of e_1 were the same in each valve, the bridge remaining balanced. Grids 4 were supplied with alternating voltages in phase opposition derived from a centre tapped transformer secondary winding, the primary being connected across a resistance in series with the load. The anode current of one valve was increased whilst that of the other was decreased, the resultant unbalance of the bridge being shown on the instrument

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[3] "Proposed Wattmeter Using Multi-Electrode Valves," *I.R.E. Proc.*, April, 1936, Vol. 24, p. 577.

connected across the diagonal of the bridge.

It is evident that the results obtained by this method of connection will be similar to those obtained by the method described in Section 2, in which e_4 is reversed in polarity to obtain the variation of anode current.

5. Experimental Procedure

The method of measurement adopted was such that it was unnecessary to measure separately the two applied grid voltages. It will be apparent from the circuit shown in Fig. 4 that these were derived from the voltage drops over the two resistances R_1 and R_2 in series, and hence only one measurement was necessary, that of current through the resistances. The R.M.S. value of the current was given by the dynamometer ammeter shown at A. The resistance R_2 was duplicated so that e_4 could be reversed in polarity merely by operating the change over switch S. A resistance of $1 M\Omega$ was connected between grid 4 and the grid bias battery B_1 in order that under no circumstances could the grid become free. Should this occur it is possible for a relatively large change of anode current to take place, damaging the anode galvanometer G. The voltage e_1 was derived from the combined voltage drops over R_1 and R_2, and when it was desired to alter the phase relationship of e_1 and e_4, also over C, which was normally shorted out. The battery B_2 supplied the necessary extra bias for grid 1. To change the polarity of e_1 the A.C. supply to the potentiometer P was reversed in polarity.

The change in anode current was measured on the multi-range galvanometer G, the steady current being "backed off" by means of the battery B_3. The current for full scale deflection of the galvanometer was 10, 100 or 1,000 microamperes according to the range in use. Screened grid and anode potentials were shown by the voltmeters V_1 and V_2, a fine adjustment potentiometer Q being provided to enable the screened grid voltage to be maintained at a constant value of 100, since a slight variation in this causes a large change in anode current and mutual conductance of the valve. For this reason it is necessary that dry batteries used for screened grid supply be in good condition, as excessive internal resistance will result in errors, since the screened grid current varies when the grid voltages are reversed in phase. The anode potential was adjusted to within about 0.75 volt, this difference from the normal value producing the small error of 0.075%. This point was dealt with in the author's previous article, in which it was shown that the approximate change of anode current and hence conductance due to a small change in anode potential was given by

$$\pm \frac{\delta E}{E + K} I_a$$

where $\pm\, \delta E$ is the change in anode potential, E is the normal anode voltage, and K is a constant, which, for the particular valve used in the tests, was 850. Thus the error is

$$\pm \frac{\delta E}{150 + 850} = \pm\, 0.001\, \delta E$$
$$= 0.1\% \text{ per volt } \delta E,$$

since the anode voltage used was 150.

The heater was supplied with a constant voltage of 2.5 from a "floating" battery.

The method of taking readings was as follows: After the valve had "warmed up" for about half an hour the operating potentials were accurately adjusted to the predetermined values, and maintained at these throughout the tests. Alternating voltages of suitable magnitudes were then applied to the grids, by adjusting the potentiometer P, and the switch S set to produce minimum anode current. The battery B_3 was then tapped at a suitable voltage so that the galvanometer reading was approximately zero. The increase of current consequent upon reversing S was noted, the range of the galvanometer being set to give the maximum readable deflection. This increase as measured was subject to corrections for the shunting effect of the resistance R_3, purposely made of high value, upon the galvanometer. When the increase was of small magnitude relative to the standing anode current it was necessary to take the mean of about four or six successive readings of increase and decrease. This eliminated the effect of slow drift in the steady anode current caused by slow battery voltage fluctuations, too small to be measured on the voltmeter but sufficient to affect the galvanometer when on its most sensitive range.

(To be concluded.)

Abstracts and References

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For the information of new readers it is pointed out that the length of an abstract is generally no indication of the importance of the work concerned. An important paper in English, in a journal likely to be readily accessible, may be dealt with by a square-bracketed addition to the title, while a paper of similar importance in German or Russian may be given a long abstract. In addition to these factors of difficulty of language and accessibility, the nature of the work has, of course, a great influence on the useful length of its abstract.

PROPAGATION OF WAVES

3231. REGULARITIES AND IRREGULARITIES IN THE IONOSPHERE.—E. V. Appleton. (*Nature*, 19th June 1937, Vol. 139, p. 1076: abstract of Roy. Soc. Bakerian Lecture.)

A survey of " the information derived from radio sounding of the ionised regions of the upper atmosphere " and a comparison of the results " with those derived from a theory of simple layer formation by solar ionising radiation, travelling rectilinearly and attenuated according to a mass-absorption law "—a " simple region." " The comparisons are concerned chiefly with the vàriation of maximum electron content N_m with solar radiation angle of incidence χ, with the total conductivity for direct currents such as determines the quiet-day magnetic variations, and with the high-frequency absorption of radio waves traversing such a region." " For the lower region E . . . . the value of N_m is found to vary, experimentally and theoretically, as $(\cos\chi)^{\frac{1}{2}}$. The high-frequency absorption . . . varies theoretically as $(\cos\chi)^{\frac{3}{2}}$." " No evidence is found suggesting the existence of permanent highly reflecting regions in the lower or middle atmosphere." " The transverse direct-current electron conductivity of a simple region is . . . found to be less than that calculated by Schuster and Chapman . . . this difficulty is met by the assumption of the existence of quantities of positive and negative ions in the lower part of the ionosphere, undetectable by radio methods, but which contribute to the conductivity for steady electromotive forces. From this assumption follows an explanation of the high effective electron recombination coefficient in the lower region."

Measurements of N_m for regions E, F_1, and F_2 support " the identification of the lower regions of the ionosphere with the levels at which flow the currents affecting terrestrial magnetism." " The two types of ionospheric abnormalities, the one associated with bright solar eruptions and the other with terrestrial magnetic storms, were compared and discussed." " An estimate of the actual heights reached by radio waves at the level of reflection leads . . . to an estimate of the proportional variation of air density with height for the ionised component." The local " scale-height " is greater in region F than in region E. " The atmosphere therefore extends to much greater heights than are estimated from the simple exponential decrease of pressure with height found in the lower atmosphere . . . the temperature at 300 km is higher than at lower levels, or it [the atmosphere] is there composed largely of a light gas such as helium. Difficulties in the way of acceptance of the latter alternative are discussed."

3232. MEASUREMENT OF THE SCATTERING REGION (G REGION) OF THE IONOSPHERE [using 5–15 m Waves: Echo of Distorted Wave Form (duration often around 0.5×10^{-3} Sec., from 10^{-4} Sec. Signal): f_G varies with Same Tendency as Max. Electron Density of F_2 Layer: etc.].—Maeda: Kirby & others. (*Electrotech. Journal*, Tokyo, July 1937, Vol. 1, No. 2, pp. 66–67.)

For Kirby's G layer see 1934 Abstracts, p. 374 (two); also 3308 of 1935. " Outside of these reports, the writer has never seen any studies made on this G layer." He believes that the Kirby results, the known short-wave scattering when a receiver is within the skip distance, and his own present results on ultra-short and short waves, are all due to one and the same scattering region. " Assuming f_G to be the frequency at which a G-reflected wave drops under the noise level, then this f_G can be made higher by increasing the transmitting power and receiving sensitivity, so that it cannot be taken as a definite critical frequency in the F_2 layer "; but the f_G mentioned in the title extension was measured with the power and sensitivity about constant. On the assumption that the long duration of the echo is due to scattered reflections in various parts, the distance over which the sources of reflection appear to extend is of the order of 150 km.

3233. Recording Ultra-High-Frequency Signals over Long Indirect Paths: Part II—A Description of the Receiving and Record-Analysing Equipment [using Bank of Thyratron-Operated Clocks as Integrator].—Hull. (*QST*, July 1937, Vol. 21, No. 7, pp. 10–12 and 78, 80.) For Part I *see* 2442 of July.

3234. The Reflection of Radio Waves in the Troposphere [Observations on C Region: High Barometer, Low C Region and *vice versa*].—R. C. Colwell & A. W. Friend. (*Phys. Review*, 1st June 1937, Series 2, Vol. 51, No. 11, p. 1005: abstract only.)

3235. Meteors and Upper Atmospheric Ionisation [Leonid Shower of 1936: No Appreciable Change in F_1 or F_2 Ionisation, Marked Increase in E_1 and E_2: Explanation by Lindemann & Dobson "Gas-Cap" Hypothesis].—J. N. Bhar. (*Indian Journ. of Phys.*, May 1937, Vol. 11, Part 2, pp. 109–118.)

For 1933 work on the E layer only *see* 1934 Abstracts, p. 314. "If . . . we remember, as has been explained above, that a region which is already ionised should undergo proportionately greater increase of ionisation than one which is not originally ionised, we easily see that the meteoric impact, instead of producing uniform ionisation [in whole mass of air between 160 and 60 km], will tend to accentuate the ionisation maxima E_1 and E_2 which are already existing."

3236. The Ionosphere and Magnetic Storms [Ionospheric Disturbances occur chiefly in Night F and Daytime F_2 Regions: Principal Effects indicate Expansion and Diffusion of F and F_2 Regions: Seasonal Variations: Recent Severe Magnetic Storms and Radio Fade-Outs: These probably produced by Different Agencies but Both associated with Active Sunspot Areas].—Kirby, Smith, Gilliland, & Reymer. (*Phys. Review*, 1st June 1937, Series 2, Vol. 51, No. 11, pp. 992–993.) *See* also 413 & 3673 of 1936.

3237. Observations of the Ionosphere made during June/July 1936 in the City of Kiev, Lat. 50° 27′ North, Long. 30° 30′ East of Greenwich [including Partial Eclipse of Sun].—S. Tetelbaum. (*Tech. Phys. of USSR*, No. 3, Vol. 4, 1937, pp. 200–223: in English.)

Observations by Bulatov are mentioned which suggest that the ionising effect, on the F region, of corpuscular radiation from the sun is of appreciable magnitude. "The abnormalities in the form of the curves throughout July 19th [eclipse] are possibly a consequence of the unusual displacement of masses of air at great heights, caused by the moon's penumbra. . . . It is possible that the regions of the atmosphere subject to the effect of the penumbra moved towards the observation point from the east towards the west [since meteor observations indicate that east winds with velocities up to 1000 km/hour exist at heights of about 40–80 km]. A future work will be devoted to a detailed examination of this question." New estimates of electron and ion densities in the D, E, and F regions are made, but it is stressed that accurate values of the ratio of ions to electrons can only be obtained when there is a reliable theory of propagation *taking friction into account*. A number of other points are discussed, and the apparatus used is described: both pulse transmitter and receiver were in the same building, only about 20 metres apart, and both were provided with a "sphere interrupter" consisting of a small suspended steel ball vibrated (by an alternating magnetic field) between two massive steel spheres. There is a list of 133 literature references. For the Russian version of the paper see *Journ. of Tech. Phys.* [in Russian], No. 7, Vol. 7, 1937, pp. 740–759.

3238. An Impulse Equipment for Investigating the Ionosphere.—S. Tetelbaum. (*Izvestiya Elektroprom. Slab. Toka*, No. 5/6, 1937, pp. 16–23.)

A rather fuller description of the equipment used during the observations referred to in 3237, above. A description is also given of a similar equipment used for an investigation of the lower layers of the ionosphere (5 to 60 km) carried out this year. Some of the oscillograms obtained during this investigation are shown.

3239. A Pyrheliometer having a Spherical Absorber is used to follow Sunspot Activities [Total Intensity Method: Comparison with Other Methods].—L. F. Miller. (*Phys. Review*, 1st June 1937, Series 2, Vol. 51, No. 11, p. 1018: abstract only.)

3240. Periodic Variations of the Ionosphere: Their Practical Effect on Short-Wave Reception.—(*Wireless World*, 2nd July 1937, Vol. 41, pp. 10–11.)

3241. The Velocity of Radio Waves over Long Distances [with Base Line of Several Hundred Miles: Timing Impulses rebroadcast to Original Station: Velocities calculated on Assumption of Reflection from E Region are much lower than Velocity of Light].—R. C. Colwell & A. W. Friend. (*Phys. Review*, 1st June 1937, Series 2, Vol. 51, No. 11, p. 990.) For previous work at shorter distances *see* 438 of February (*cf.* also 2050 of June). The go and return frequencies used in the present work were 14 160 and 14 186 kc/s respectively.

3242. Measurements of Pressures in the Upper Atmosphere [by Simultaneous Observation of Ratio of First-Negative to Second-Positive System of Nitrogen Bands in Auroral Display and of Auroral Height].—J. Kaplan. (*Nature*, 26th June 1937, Vol. 139, p. 1112.)

3243. Intensity Variations of the Green and Red Oxygen Lines and the Occurrence of the ϵ-System [of Nitrogen Bands] in the Aurora and Light of the Night Sky.—L. Vegard. (*Zeitschr. f. Physik*, No. 1/2, Vol. 106, 1937, pp. 108–131.)

3244. What is the Origin of the Particles in the Aurora Borealis? [Theoretical Explanation of Production of Charged Particles of Great Energy in the Sun with the Help of the Magnetic Fields in Sunspots].—H. Alfvén. (*Zeitschr. f. Physik*, No. 9/10, Vol. 105, 1937, pp. 633–641.)

3245. The Diffraction of Electromagnetic Waves from an Electrical Point Source round a Finitely Conducting Sphere, with Applications to Radio-Telegraphy and the Theory of the Rainbow: Part I.—B. van der Pol & H. Bremmer. (*Phil. Mag.*, July 1937, Series 7, Vol. 24, No. 159, pp. 141–176.) An exposition, with numerical results, of the mathematical method of Watson.

3246. Propagation of Potential in Discharge Tubes [Experimental Values of Velocity in Dry Air for Varying Pressure and Tube Diameter: Speed greater for Negative than for Positive Impulses: Linear Speed/Voltage Curve at Constant Pressure].—Snoddy, Dietrich, & Beams. (*Phys. Review*, 1st June 1937, Series 2, Vol. 51, No. 11, p. 1008: abstract only.) Work already referred to in 2878 of August.

3247. The Electric Spectrum of Liquid Water from Five to Twenty Centimetres [Refractive and Absorption Index: No Evidence of Dispersion: Calculated Relaxation Time].—H. W. Knerr. (*Phys. Review*, 1st June 1937, Series 2, Vol. 51, No. 11, p. 1007: abstract only.)

3248. A Measurement of the Velocity of Light [Kerr-Cell Modulation Method requiring only Short Base Line].—W. C. Anderson. (*Review Scient. Instr.*, July 1937, Vol. 8, No. 7, pp. 239–247.)

ATMOSPHERICS AND ATMOSPHERIC ELECTRICITY

3249. Lightning.—Goodlet. (*Journ. I.E.E.*, July 1937, Vol. 81, No. 487, pp. 1–26.)

See 2886 of August. Long Discussions follow on pp. 26–56: Appendix I is described as "an outstanding contribution to the subject, of great originality. I refer to the part which deals with the mechanism of the discharge stroke, and which imports quantitative ideas into the first qualitative outline that Sir George Simpson gave us."

3250. Comparison of the Spectra of Lightning Flashes with the Spectra of Nitrogen Bands excited by Electronic Bombardment.—Bernard. (*Journ. de Phys. et le Radium*, May 1937, Series 7, Vol. 8, No. 5, p. 65S.)

Extension of the writer's work on auroral spectra (2069 of June) to lightning spectra. "The agreement of these values allows it to be supposed that the spectrum is excited by well defined shocks of energy; but the considerable development of the rotation components of the various bands is incompatible with an excitation of electronic origin. It must be concluded, therefore, that heavier particles are involved, probably ions created by the actual passage of the flash, which excite the neighbouring layers of air. These ions would rapidly reach a velocity limit of 12 km, corresponding to the calculated mean energy of 22.2 ev."

PROPERTIES OF CIRCUITS

3251. A New Theorem on Electrical Networks [connecting Final Steady State with A.C. Admittance or Impedance: derived (by Symbolic Calculus) from Heaviside's Remark on "Pseudo Heat Dissipation"].—B. van der Pol. (*Physica*, July 1937, Vol. 4, No. 7, pp. 585–589: in English.)

The new theorem is: "The ratio of twice the excess of the magnetic energy over the electric energy to the heat dissipation per second, all in the final, steady state, equals the differential of the logarithm of the impedance with respect to $j\omega$ at the frequency $\omega = 0$." A deduction is that "the efficiency with which a battery can be made to charge a system of condensers (any resistances and inductances being present in the circuit) is always 50%."

3252. Transformation Formulae of Impedances and Admittances in the Method of Symmetrical Coordinates [using Matrix Theory].—S. Koizumi. (*Phil. Mag.*, July 1937, Series 7, Vol. 24, No. 159, pp. 195–206.)

3253. General Equaliser Theory, Two-Terminal and Constant-Resistance Structures: Part II.—F. M. G. Murphy. (*Marconi Review*, March/April 1937, No. 65, pp. 20–26.)

Second and final part of the work referred to in 2485 of July. Design methods: intervalve correctors: inverse and equivalent networks: example of use of formulae for practical design.

3254. Using the R.F. Charts [for Band-Pass R.F. Circuits].—Nachod. (*See* 3285.)

3255. Resistance Control of Mutual Inductance Coupling between Two Tuned Circuits.—Sturley. (*See* 3287.)

3256. The Magneto-Ionic Coupling of Two Electric Circuits.—V. F. Makarov. (*Izvestiya Elektroprom. Slab. Toka*, No. 4, 1937, pp. 19–20.)

An inductance coil connected to the primary circuit is wound round a gas-filled tube, the two electrodes of which are connected to the secondary circuit. When an alternating voltage equal to or exceeding the striking voltage of the tube is applied to the coil, the gas in the tube becomes ionised and an alternating current of the same frequency flows through the tube.

3257. Electronic Mutual Coupling between Resonant Circuits, and Automatic Selectivity Control.—Boella. (*See* 3286.)

3258. On the Problem of the Control of Frequency by Variation of Voltage: the Valve as a Variable Capacity: Automatic Tuning Correction [and Other Applications].—W. Engelhardt. (*Funktech. Monatshefte*, June 1937, No. 6, pp. 175–179.)

"To sum up, it may be said that fundamentally a control of frequency by means of an auxiliary valve is possible. The amount of maximum frequency change is limited by the increasing losses in the oscillatory circuit and depends on the working frequency. For ATC of broadcast receivers the circuits described can, with suitable values, be applied without modification: they have, indeed, already been tried in practice. Similarly, nothing stands in the way of their use for measuring purposes [*e.g.* " howlers " for frequency analysis, etc.], provided that only small frequency changes, or the variation of comparatively low frequencies only, are required. But when (as in the distant control of a single-span receiver) large frequency changes such as 1000 kc/s or over are necessary, with a basic frequency which is comparatively high, then the circuits are unsatisfactory owing to the high losses."

3259. The Transformer: Its Mode of Action and Equivalent Circuit.—F. Bergtold. (*Funktech. Monatshefte*, June 1937, No. 6, pp. 179–182.)

3260. Tuned Lines as Reactances [Comparison with Circuit containing Lumped Inductance and Capacitance: Effect of Line Resistance on Resonance-Amplitude and Frequency Characteristic: Series and Parallel Resonance: etc.].—Bell. (*Marconi Review*, March/April 1937, No. 65, pp. 27–30.) A revised treatment of the problem dealt with in part of the author's paper " Oscillators stabilised by Resonant Lines " (938 of March).

3261. On the Simultaneous Use of Positive and Negative Feedback [Some Special Applications of the Principle: Frequency Stabilisation, with Quartz Oscillator or (for Ultra-Short Waves) Resonant Lines].—P. Pontecorvo. (*Alta Frequenza*, July 1937, Vol. 6, No. 7, pp. 448–452.)

A letter prompted by Vecchiacchi's paper (2923 of August): the writer and his colleagues have been working independently on the same principle. A modification of Vecchiacchi's method of obtaining negative current-controlled feedback is to replace the ohmic resistance r (Vecchiacchi Fig. 4) by a series-resonant LCR circuit, giving a negative feedback which is a function of frequency: the next step is to substitute a quartz plate in place of the resistance, giving a very stable oscillator, particularly for frequencies such as 50–100 kc/s. Fig. 4 of the present paper shows the appllication of the principle to ultra-short-wave frequency stabilisation with the help of resonant lines, making use of the fact that an $\lambda/2$ line with one open end presents at the other end an impedance resembling that of an anti-resonant circuit, whereas a similar line with an end short-circuited presents one resembling that of a series-resonant circuit. Experimental confirmation of the scheme is pending.

3262. Distortion in Negative Feedback Amplifiers [Effect of Difference between Taylor and Fourier Series].—J. Frommer: Sloane. (*Wireless Engineer*, July 1937, Vol. 14, No. 166, p. 369.)

Criticism of Sloane's analysis (2486 of July). A pending paper from the Tungsram laboratories, on the exact treatment of the diminution of the terms of the Fourier series of an amplifier, by negative feedback, is quoted from.

3263. Inverse Feedback: a New " Series " Circuit [Feedback Voltage tapped off Voltage Divider across Output Load and fed, in Series with Output of Preceding Valve, to Grid of Output Valve].—Amalgamated Wireless Valve Company. (*Rad. Review of Australia*, March 1937, Vol. 5, No. 3, p. 64.)

3264. " Kipp Generators " [Relaxation Oscillation Circuits] with High-Vacuum Valves.—G. Faust. (*Funktech. Monatshefte*, June 1937, No. 6, pp. 183–192.)

Author's summary:—Taking as an example a glow-discharge-tube " kipp " circuit, the theoretical foundations of " kipp generators " are considered. Since the glow-discharge tube behaves in an unstable manner, the results of these formulae, and the influence of the various component values, are investigated experimentally as applied to a circuit imitating a glow-discharge-tube circuit but employing high-vacuum valves. Discrepancies in the measured percentage fly-back times show that the theoretical formulae require extension by a time which corresponds to the time constant of the components, and which renders the circuit unsuitable for high frequencies. In order to make this time constant ineffective, two " kipp " circuits with inductances were developed which gave high frequencies with sufficiently short percentage fly-back times [Fig. 18, where the cathode-drop resistance R_2 of Fig. 3 is replaced by a capacity-shunted inductance L (this circuit fails above about 200 kc/s because the retroactive coupling through the resistance R_1 becomes too weak), and Fig. 25, where R_1 also is replaced by an inductance L_R, which is coupled to the oscillatory circuit LC_1. This arrangement works up to 4 Mc/s].

TRANSMISSION

3265. The Posthumus Oscillations in the Magnetron.—F. Fischer & F. Lüdi. (*Bull. Assoc. suisse des Élec.*, No. 13, Vol. 28, 1937, pp. 277–283: in German.)

The writers first describe the three chief types of magnetron oscillation—electronic, involving a " sorting-out " process such as that taking place in the retarding-field valve (*see* for example Dick, 2120 of 1936) and occurring in both split- and unsplit-anode magnetrons; the Posthumus type (" rotating field ": *see* 1370 of 1935); and the Habann (" negative-resistance ") type—*see* for example Herriger & Hülster, 1319 of April. For the rest of the paper they concentrate on the Posthumus type.

Authors' summary:—" By examination of the cycloidal motion between two flat plates, the upper of which is provided with slits, the writers show that on the assumption of a steady electric field between the upper and lower plates and a rotating field superposed at the upper plate, the electrons giving up energy return to the anode and the electrons absorbing energy return to the cathode. All the electrons returning to the anode give up to the latter the same amount of energy. In the limiting case of a cycloidal height small compared with the distance between the plates, the efficiency is consequently 100% [this occurs chiefly at long waves, where strong magnetic field are employed]. For cycloidal heights comparable with the distance between plates, the efficiency falls; it can, however, always remain greater to that of the first type of oscillation because, with Posthumus oscillations, there exists a characteristic difference in the second 'sorting-out' mechanism as compared with that of the first type of oscillation. 'Ziehen' effects [back-lash: much more pronounced with the Posthumus type than with the electronic type—"oscillation broke off from high oscillatory current values suddenly at 900 v and set in again, with almost the same high value, equally suddenly at 950 v"] are explained by the ratio of the cycloidal height to the cathode/anode gap" [greater back-lash, the smaller the cycloidal height compared with the gap].

Implications of the writers' views, as regards the failure of certain methods of modulation, are set out, and in the final paragraph Fritz's result (1736 of 1936) on the ineffectiveness of modulation by end plates is explained. Examples are given (pp. 282–283) of the calculation of the voltages and magnetic fields necessary to give efficiencies over 50% on the shorter wavelengths; large discrepancies between the calculated results for 50 cm and the experiemental values obtained with a Philips 4-slit magnetron are explained. For 10 cm the calculated field and voltage are both enormous.

3266. On the Mechanism of Magnetron Oscillations of Type B [in Split-Anode and Electron-Beam Magnetrons: based upon "Reversed Action of a Cyclotron or Reversed Phase Relation between H.F. Voltage and H.F. Current"].—K. Okabe. (*Electrotech. Journal*, Tokyo, July 1937, Vol. 1, No. 2, p. 69.) For the "electron-beam" magnetron *see* 2966 of August.

3267. On the Action of a Homogeneous Magnetic Field on the Motion of Electrons between Coaxial Cylindrical Electrodes.—Grünberg & Wolkenstein. (*See* 3308.)

3268. A Push-Pull Circuit for Ultra-Short Waves, using Water-Cooled Pentodes.—Posthumus. (*See* 3321.)

3269. Frequency Stabilisation of Ultra-Short-Wave Transmitters by Simultaneous Positive and Negative Feedback.—Pontecorvo. (*See* 3261.)

3270. Tuned Lines as Reactances.—Bell. (*See* 3260.)

3271. High-Frequency Modulation of Ultra-Short Waves.—Banerjee & Singh. (*See* 3395.)

3272. An Effective Linear Filter for Harmonics: Suppression of Even and Odd Harmonics with an Inexpensive and Easily-Constructed Transmission Line [for Short and Ultra-Short Waves: "Quarter-Wave Stubs"].—J. N. A. Hawkins. (*QST*, July 1937, Vol. 21, No. 7, pp. 19 and 62.)

3273. A Fundamental-Reinforced Harmonic-Generating Circuit: Efficient Frequency Multiplication for Four-Band Output from a 3.5 Mc/s Crystal.—J. L. Reinartz. (*QST*, July 1937, Vol. 21, No. 7, pp. 15 and 82, 84.)

3274. An Oscillator with a Thermal and Electro-Parametric Stabilisation of Frequency for use in Short-Wave Transmitters.—V. A. Smirnov. (*Izvestiya Elektroprom. Slab. Toka*, No. 4, 1937, pp. 14–17.)

Description of an oscillator with a thermal control and compensation of various constants, using a modified Dow circuit with electron coupling, and covering a frequency range of 4000–8500 kc/s. The frequency stability is within 0.01%.

3275. The Energy Relations in Radio-Telephony.—S. I. Tetelbaum. (*Journ. of Tech. Phys.* [in Russian], No. 8, Vol. 7, 1937, pp. 822–835.)

In calculating the energy relations in a radio transmitter operating on telephony, it is usual to assume that the modulating voltage is a sinusoidal function. In certain cases, however, this assumption may lead to incorrect conclusions, and it is suggested that the calculations should be based on a statistical study of "equivalent modulation curves," *i.e.* energy summation curves each corresponding to a modulating voltage taken over a considerable time interval (1 min.). The theory of the equivalent curves is discussed and a graphical method is suggested for plotting them. Since, however, this method is rather laborious, a special circuit was developed to which electrical oscillations corresponding to a gramophone record were applied, and the output fed to a hydrogen voltammeter consisting of a calibrated test tube containing a solution of sulphuric acid. By measuring the volume of hydrogen liberated in the test tube when a record is played, the equivalent curve can easily be plotted both for ordinary amplitude modulation and for the writer's "constant-depth" modulation (2507 of July).

A number of such curves, corresponding to records of various types of music and speech, are given and a comparison is made between the two systems of modulation. It is shown that for equal effects at the receiving point the power consumption, anode dissipation, and energy radiation of a transmitter with "constant-depth" modulation are 60%, 65% and 50% of the corresponding values of a transmitter using ordinary amplitude modulation (on the grid).

3276. The Occurrence and Measurement of Sideband Asymmetry (Phase Modulation).—R. Hofer. (*Telefunken* [formerly *Telefunken-Zeitung*], July 1937, Vol. 18, No. 76, pp. 71–83.)

Author's summary:—"The conditions for a distortionless h.f. transmission are set forth and the various causes of disturbance of sideband symmetry liable to be present in valve transmitters are described. After a short review of existing methods, a very exact method of measuring phase modulation, particularly suitable for the measurement of the sideband displacement produced by asymmetry in the h.f. circuit, is discussed in detail [*see* below] and the practical design of the apparatus described. In an Appendix a general expression for the ideal rectification action is derived, with the help of which the distortions are calculated which occur in the linear rectification of a modulated oscillation whose symmetry has been upset. The dependence of these wave-form distortions on the magnitude of the amplitude and phase asymmetries is shown in a diagram ['klirr' factor curves of Fig. 105, for various values of g, the amplitude ratio: the $g = 1$ curve is thus the curve of pure phase asymmetry, the amplitude asymmetry increasing as g decreases]. Finally, the writer determines the value of the heterodyning amplitude necessary for obtaining an adequate accuracy of measurement" [with the method described: so that interference by the unwanted notes due to the first rectification—*see* below—may be avoided].

The measuring method described falls into two parts: first the measurement of amplitude with the help of a h.f. exploring frequency (as used by Grützmacher and Runge—*see* for example 1931 Abstracts, p. 149, Runge: also *cf.* 3366 & 3367, below) and then the determination of the sideband phase position. The latter process is fundamentally as follows:—the heterodyne frequency being kept constant, the beat frequency δ from the first detection is separated by a selective circuit from the two sideband heterodyned frequencies $\Omega \pm \delta$ and doubled to 2δ (by a pair of valves with grids in push-pull and anodes in parallel), while the sideband heterodyned frequencies are again rectified: the result being that two oscillations of the doubled frequency 2δ are obtained, whose phase-difference angle 2χ is proportional to the required angle χ and is measured by the thermo-junction bridge circuit B_3 (Fig. 103) which forms a phase indicator independent of frequency.

3277. MODULATION ON THE ANODE IN THE OVER-EXCITED RÉGIME.—S. I. Evtyanov. (*Izvestiya Elektroprom. Slab. Toka*, No. 6, 1936, pp. 1–13.)

"The impossibility of obtaining high modulation with valves having 'right' characteristics [operating within region of positive grid bias, with grid current flowing most of the time], when the plate oscillating voltage is low, is shown in the article. High and linear modulation is possible when the whole modulation curve is located in a state of high plate oscillating voltage. The principles of modulation in this state differ from those in the state of low plate oscillating voltage; a modulation occurs because of the deformation of the plate current impulse as a consequence of redistribution of emission between plate and grid circuits . . ." The treatment is based on the supposition that the dynamic characteristic of the plate current in a state of high oscillating voltage has the form of a triangle (*see* also 58 of January and 2594 of July).

3278. MODULATION ON THE ANODE [including the Selective Properties of the Load Impedance: Combined Anode and Grid Modulation].—L. Rubin. (*L'Onde Élec.*, June 1937, Vol. 16, No. 186, pp. 374–386: to be contd.)

"Modulation on the anode, primitively employed in the form of 'constant-current modulation,' has for some little time returned to favour . . . If one has a sufficiently complete collection of static characteristics, known graphical methods permit the exact calculation of the working conditions of the modulated amplifier; this calculation can be facilitated by the use of constant-current characteristics (Mouromtseff & Kozanowski—3389 of 1935). On the other hand, certain writers have proposed analytical methods based on special forms of dynamic characteristics (Evtyanov—58 of January, 2594 of July, and 3277, above). These different graphical and analytical methods only apply, however, to the examination of isolated cases. We, on the contrary, propose to study, in this paper, the problem of anode modulation in a more general form. Without straining for numerically exact results, we shall try to show the nature and the order of magnitude of the phenomena taking place in the circuits of all the modulated amplifiers."

The modulated amplifier should be adjusted so that the relation between its output voltage and the voltage applied to the anode is practically linear; at the same time, this linearity must be obtained in good conditions of power and efficiency. Such a result is obtained in practice by making the amplifier work in Class C (for the carrier wave) and using positive grid voltages. The writer therefore deals with the Class C amplifier and its modulation, using a diagram established specially for this purpose. This is based on a family of modulation characteristics valid only for under-excited amplifiers (hypothesis of linear static characteristics—*see* 101 of 1935 and 86 of 1936) on which are superposed the straight lines AA, representing the d.c. anode voltage, and BB, representing the boundary of the over-excited condition. "The modulation characteristics of Fig. 2 have been calculated on the assumption that the load impedance of the amplifier is real and constant for all the frequencies composing the modulated oscillations. This impedance generally consists of one or more anti-resonant circuits tuned to the carrier frequency . . . ," and though for the lower frequencies the characteristics are valid, for the higher frequencies the de-phasing and amplitude modifications of the sidebands introduced by the load impedance must be allowed for (pp. 382–386). For example, in a circuit whose resonance coefficient is 15, de-phasing of the sidebands is evident even for a ratio f/F of 0.01. The construction of the corresponding diagram for the case of simultaneous anode and grid modulation is described on pp. 381–382. In the next instalment the question of efficiency, power, and linearity will be considered.

3279. EXPERIMENTS ON SINGLE-SIDEBAND MODULATION, WITH FREQUENCY DIVERGENCIES OF THE REPLACED CARRIER.—Schaffstein. (*See* 3282.)

3280. A STEP TOWARD VOLUME COMPRESSION, *and* AUTOMATIC GAIN CONTROL [adapted for Programme Control].—Western Electric: Jordan. (*See* 3543 & 3542.)

3281. A NEW METHOD FOR DIPLEX C.W. TELEGRAPHY.—P. I. Evdokimov. (*Izvestiya Elektroprom. Slab. Toka*, No. 4, 1937, pp. 6–14.)

For a previous paper on the general problem *see* 4019 of 1936. In this method the aerial currents corresponding to the two messages are of the same frequency but are displaced in phase by 120°. The sum of the two currents is thus equal in magnitude to each individual current but is displaced by 60° from each. The aerial current is consequently the same in amplitude whether either or both signals are transmitted. At the same time the radiated frequency band depends on the speed of telegraphy only and is not extended when two messages are transmitted. A suitable transmitting circuit (Fig. 2) is suggested, and an analysis is given of its operation showing that the above conditions are satisfied. A phase-selector circuit (Fig. 5) suitable for aural reception (and with certain modifications for automatic reception as well) is described and its operation discussed. The maximum permissible frequency variation and phase displacement of the oscillator in the receiving circuit are determined, and methods are indicated for meeting these requirements.

RECEPTION

3282. EXPERIMENTS ON SINGLE-SIDEBAND MODULATION, WITH FREQUENCY DIVERGENCIES OF THE REPLACED CARRIER AT THE RECEIVER.—G. Schaffstein. (*Telefunken* [formerly *Telefunken-Zeitung*], July 1937, Vol. 18, No. 76, pp. 62–66.)

The tests were on a 300 m wave, and an ordinary broadcast receiver was used, with a separate generator for the replaced carrier. As regards periodic processes, the already known effects were found—namely that a frequency divergency of the replaced carrier adds or deducts itself to each of the previously mutually harmonic frequencies present after demodulation, and thus renders them no longer harmonic to each other, with the result that music sounds strongly distorted, "rather like a de-tuned piano." A frequency error of about 1 c/s is noticeable in music, and of about 10 c/s in speech.

The tests on aperiodic processes showed that, with these, such a carrier-frequency divergency produced further very objectionable phenomena: thus clicks, produced by making and breaking a d.c. current through the input transformer of the modulation amplifier, are transformed by a carrier de-tuning of 1000 c/s into prolonged notes like those of a struck wine glass or violin string. This phenomenon is explained with the help of the oscillograms of Figs. 84 & 85; it is noticeable with divergencies as small as 50–100 c/s, and must be even more serious for the intelligibility of speech than the harmonic phenomenon first mentioned, since this chiefly affects the intelligibility of the vowel signs, whereas the predominant action of the second effect is on the consonants, particularly the "explosion" sounds *d*, *p*, *k*, and *t*. The final section deals with a phenomenon which occurs when the receiver output is back-coupled to the l.f. input of the single-sideband transmitter. In such a case there is liable to be self-excitation if the local carrier is exactly in tune with the original carrier, and if the back-coupling is strong enough; but such self-excitation would not be expected to occur if the local carrier were detuned by (say) 5 c/s, since the demodulated note from the receiver would also be 5 c/s out of tune. It does occur, however, and produces a vigorous caterwauling if the replaced carrier-frequency is too low, and a different noise if it is too high. An explanation is suggested, and it is mentioned that the phenomenon can be of practical use for the comparison of two frequencies, and in particular for the accurate adjustment of the replaced carrier in single-sideband telephony.

3283. QUARTZ RESONATORS [as distinct from Quartz Oscillators].—R. Bechmann. (*Telefunken* [formerly *Telefunken-Zeitung*], July 1937, Vol. 18, No. 76, pp. 5–15.)

The development of quartz resonators has been somewhat neglected in favour of that of quartz oscillators (*cf.* 1741 of 1936), although the resonator was the original form in which quartz plates were used in radio technique. Lately, however, interest in resonators has been revived in connection with selective devices in transducer circuits, and particularly in the i.f. circuit of superheterodyne receivers. The oscillator differs from the resonator in that its interest is chiefly concentrated in the properties of one very strongly marked resonance point, whereas the important characteristic of a resonator is the behaviour over a more or less extensive zone around the resonance point. A quartz resonator may be treated as a mechanical resonator with a retroaction (due to its piezo-electric effect) on an electrical field; at a first approximation the natural frequency can be calculated without taking into account this electrical retroaction, which actually affects the value slightly. On the other hand, the resonator can be treated as an electrical circuit component and represented by an electrical equivalent. circuit. Since both procedures must arrive at the same result electrically the values in this equivalent circuit can be deduced from the mechanical and electro-mechanical values of the mechanical resonator. Once this equivalent circuit is accurately known, together with its limits of applicability, the theoretical problem of the quartz resonator is solved. All combinations in transducer circuits, filter circuits, etc., can be treated by ordinary circuit theory by the use of this equivalent circuit.

The complete equivalent circuit of a resonator (only the case of *two* electrodes, parallel to the surfaces of the quartz plate or rod, is considered) is seen in Fig. 1; in the special case of the electrodes touching the quartz, C_2 becomes infinitely large and the simpler circuit of Fig. 2 is obtained. But Watanabe has shown also that Fig. 1 can always be transformed into the simpler circuit of Fig. 2, the transformation equations being given in eqns. 1: "this seems reasonable physically, since the fundamental behaviour of a quartz resonator is independent of the electrode distance." The curve of reactance of Fig. 1 is shown in Fig. 3: it has a series resonance point (eqn. 2a) as well as a parallel (eqn. 2b), the frequency interval between them being given by eqn. 2c; this simplifies to 2d if the electrodes touch the quartz so that C_2 becomes infinitely large. Using the transformed circuit of Fig. 2, the corresponding equations are 3a, b, & c. For oscillators, either the series or parallel resonance points may be used, according to the circuit: but for resonators the series resonance is of predominant importance (last paragraph, p. 7). The derivation of the component values of the electrical circuit of Fig. 1 from the electro-mechanical data is dealt with, for the "thickness" vibrations of variously oriented plates, on pp. 8–10, and the writer then goes on to give an exact definition of the "single-resonance" and "multi-resonance" properties of a quartz crystal ("einwelligkeit" and "mehrwelligkeit"): the terms are used by various workers with various meanings, leading to frequent misunderstandings. "By a 'multi-resonance' effect of a quartz plate we mean expressly the special phenomenon that in place of a single anticipated resonance point a multiple resonance point appears." Thus, referring to wedge-shaped resonators, formerly claimed to present a continuous spectrum between the frequencies corresponding to the greatest and least thicknesses, the writer maintains that on the contrary such a resonator has numerous discrete resonance points, each of which may be multi-resonant.

Such multiple resonance is discussed with the aid of resonance curves (Figs. 6–10) taken, with the automatic recording apparatus shown in Fig. 4, from various types of plate. "The formation of multiple resonances is in general independent of the orientation of the plate: for all orientations it is possible to prepare perfect, single-resonant resonators"; one important factor is to start with a pure material, another is to avoid coupling effects (between, for instance, the fundamental of a thickness vibration and the harmonic of a transverse vibration) by the choice of a suitable shape and suitable proportions. A final section deals with bridge-circuit, coupling, and parallel-tuned-inductance methods of compensating for the self-capacity of the quartz unit, in order to increase the selectivity for use in superheterodyne receivers. These arrangements can also be employed to give a continuous band-breadth variation. Adjustable electrode spacing, which in *oscillators* is used to adjust exactly to the required frequency, can be employed in *resonators* to vary the equivalent circuit so as to obtain optimum matching with the rest of the associated circuit.

3284. Quartz Filters with Continuously Variable Band Breadth [*e.g.* from 20–5000 c/s without Appreciable Change of Height or Position of Resonance Peak: for Superheterodyne Receivers].—W. Kautter. (*Telefunken* [formerly *Telefunken-Zeitung*], July 1937, Vol. 18, No. 76, pp. 22–41.)

After an introductory section on the use of such filters, the writer discusses the equivalent circuit of a quartz resonator, passes on to a short description of the equipment (high-sensitivity valve voltmeter reading from 100 μv to 1 mv with normal scale, or to 140 mv with logarithmic scale; motor-driven "fine tuner" for varying the generator frequency; etc.) used for the automatic recording of filter curves and for other measurements, and discusses the procedure and its theory. Although the finely-tuned generator can be read to 40 c/s, the quartz damping cannot be measured by the usual technique of raising the generator voltage $\sqrt{2}$ times, since the corresponding small band width is not readable. The generator voltage is therefore increased ten times and the band width measured: it is ten times the true width. The last section of Part I deals at length with the three ways of neutralising the parallel capacity of the quartz, already discussed more briefly by Bechmann (3283, above).

In Part II we come to the actual variation of band breadth. Section 1 deals with a filter with "single-sided" regulation, accomplished by varying the tapping-point, on the ohmic resistance R_a in the anode circuit of one valve, to the quartz which acts as a link to the grid of the next valve. The "off-resonance" selectivity ψ_{max} ("Weitabselektivitat": the greatest value of suppression which the filter can exert at a certain distance from the resonance peak) depends on the type of neutralising circuit (pp. 34–35) and falls sharply as the band width increases. Section 2 deals with "two-sided" regulation, the quartz being connected between two oscillatory circuits which are varied simultaneously. The variation may be (a) by varying the couplings (inductive, direct galvanic, or capacitive) to the two circuits, or (b) by de-tuning the two circuits either in the same sense with regard to the quartz resonance frequency or in opposite senses. Both (a) and (b) give the same results, but (b) is somewhat easier to carry out in practice. Section 3 deals with a filter in which the quartz is employed no longer as a coupling link between two valve circuits but, without any neutralisation, as an anode resistance (Figs. 64, 65): use being made of the shape of the impedance characteristic (quartz with parallel circuit of various de-tunings) seen in Fig. 54b. This arrangement gives a rather higher amplification than the "two-sided" filter of Section 2 (which itself gives a better amplification, at any rate at high intermediate frequencies, than the "single-sided" type—*see* bottom of p. 32). Its band-width regulation is based on the impedance curve mentioned above, and is accomplished by varying the de-tuning, from the quartz resonance frequency, of the parallel oscillatory circuit. In spite of the different construction of this filter, the same formulae apply for the dependence of amplification on band width.

3285. Using the R.F. Charts [for Design of Band-Pass R.F. Circuits for Broadcast Receivers].—Nachod. (*Rad. Engineering*, June 1937, Vol. 17, No. 6, pp. 19–20 and 31.)

On the use of the nomograms dealt with in 1725 of May. Their importance is increased by the fact that "the time must eventually come when the standards of high-fidelity reception will demand that serious attention be given to the use of band-pass circuits not only in the i.f. amplifier but in the pre-selector stages as well."

3286. Electronic Mutual Coupling between Resonant Circuits and [Its Application to] Automatic Selectivity Control.—M. Boella. (*Alta Frequenza*, July 1937, Vol. 6, No. 7, pp. 425–434.)

Author's summary:—"The essential characteristic which differentiates the electric from the electronic type of coupling between resonant circuits is explained, and it is shown how a mutual electronic coupling can be obtained which is equivalent to the electric type as regards the shape of the resonance curves given by the two systems. This equivalence is shown analytically for the fundamental case of two coupled circuits, and the extension to two pairs or groups of circuits is given. The experimental results obtained with a system of four circuits are described, and finally the application of mutual electronic coupling devices to automatic selectivity control in radio receivers is considered." The writer concludes: "This principle . . . which is susceptible of important developments, provides a rational and promising solution to the problem of automatic selectivity control." Fig. 11 gives a suitable circuit diagram, the pentode 6A7 providing a unilateral inverse link by mutual electronic coupling. Hand control of grid bias furnishes an additional adjustment to suit the particular conditions of reception and the tastes of the user.

3287. Resistance Control of Mutual Inductance Coupling between Two Tuned Circuits [Theoretical and Experimental Investigation with View to Use for Variable Selectivity Control: Unsatisfactory for Double-Sideband Reception, Possible for Single-Sideband and for Correction of Asymmetry of Coupled-Circuit Selectivity Curves].—K. R. Sturley. (*Marconi Review*, March/April 1937, No. 65, pp. 1–8.)

3288. The Valve as Variable Capacity, and Its Use for Automatic Tuning Correction.—Engelhardt. (*See* 3258.)

3289. Arrangement for Compensation of the Weakening of the High Modulation Frequencies caused by Too Narrow Resonance Curves [in Apparatus with Automatic Fading Compensation: Small Time Constant of Amplifier Regulation weakens Low Frequencies].—E. Zepler: Telefunken. (*Hochf:tech. u. Elek:akus.*, June 1937, Vol. 49, No. 6, p. 215: German Patent 642 761 of 18.9.35.)

3290. The Equivalent High-Frequency Voltage Source of an Apparatus causing Broadcast Interference.—R. Feldtkeller. (*Hochf:tech. u. Elek:akus.*, June 1937, Vol. 49, No. 6, pp. 199–205.)

For previous work see *Veröff. aus dem Gebiet der Nachrichtentechnik* (Siemens), Vol. 4, 1934, p. 107. This is here continued with a calculation (§ III) of the errors arising when the voltages produced by a source of broadcast interference are considered as arising from a symmetrical and an asymmetrical equivalent voltage source. The voltages on the terminals of an interference source which is almost symmetrical as regards resistance are worked out in § II; the errors are tabulated in § III and discussed. It is found that the division mentioned above is unreliable even when the asymmetry of the internal resistances is small. Simple methods of measuring the terminal voltages are discussed in § IV; the effect of deviations from the average mode of representation of the mains is estimated in § V. It is found, for example, that the sensitivity to earth resistance is greatest when the source of disturbance is earthed and matched to the mains; it is proportional to the original asymmetrical voltage and to the asymmetry of the resistance. Calculations of the terminal voltages are given in an appendix. For other papers by the same writer on broadcast interference *see* 1934 Abstracts, pp. 102–103, and 1764 of May.

3291. The See-Saw Noise Silencer [Reverse-Diode "Gate" in Automatic Circuit].—B. S. McCutchen & D. A. Griffin. (*QST*, July 1937, Vol. 21, No. 7, pp. 13–14 and 56, 58, 60.)

3292. Amplitude Limiting in the Aural Reception of Telegraphic Signals [Investigation on Limiting by Copper-Oxide Rectifiers (Unbiased and Biased) and the Resulting Reduction of Errors].—Dannehl, Kotowski, & Picker. (*Telefunken* [formerly *Telefunken-Zeitung*], July 1937, Vol. 18, No. 76, pp. 50–61.) Wrong letters can thus be reduced to 30 or 40% of the normal number.

3293. Low-Distortion Diode Detection: New Circuit eliminates Shunting Effects.—Amalgamated Wireless Valve Company. (*Rad. Review of Australia*, March 1937, Vol. 5, No. 3, pp. 70–71 and 84.)

3294. Advanced Receiver Design.—Beard. (*Electronics*, July 1937, Vol. 10, No. 7, p. 44.) Summary of paper dealt with in 2927 of August.

3295. The Double Superheterodyne Receiver [General Principles: Choice of 1st and 2nd I.Fs: Necessity for Rough Pre-Selection: Final Circuit: Special Components for Frequency Stability: Reasons for No Commercial Production].—R. I. Kinross. (*Wireless Engineer*, July 1937, Vol. 14, No. 166, pp. 351–358.) From the Electric & Musical Industries laboratories.

3296. The Superhet: Is it the Set of the Future?—R. W. Hallows. (*World-Radio*, 18th June 1937, Vol. 24, pp. 10–11.)

3297. The Case for Class "B" [for Battery-Driven Receivers] Restated: Refinements applicable to the Negatively Biased System.—R. H. McCue. (*Wireless World*, 9th July 1937, Vol. 41, pp. 28–29.)

"The later type of double-triode, operating with a bias of several volts, undeservedly inherited this slur ["Class B edge" given by zero-bias Class B systems] and, in fact, has not attained the popularity which it merits." It is capable of a high standard of reproduction, provided the refinements here described are observed.

3298. The Broadcast Receiver as a Problem of Materials: the Opening of the State Exhibition "Schaffendes Volk" ["A Nation at Work"], Düsseldorf, 1937.—E. Schwandt. (*Funktech. Monatshefte*, June 1937, No. 6, pp. 193–197.)

Among the materials mentioned are Mipolam, Plexiglas, Astralon, Stabol, and Buna. "Four Year Plan" economy in the use of metals includes the use of welded in place of soldered joints, metallisation of insulating carriers (*e.g.* for condenser plates) and the use of bi-metallic in place of solid noble-metal contacts.

3299. CATHODE CONDENSER AND THE LOW FREQUENCIES [with Curves giving Relation between Cathode (Automatic Grid Bias) Resistance and By-Pass Condenser].—H. Hertel. (*Funktech. Monatshefte*, June 1937, No. 6, pp. 197–198.)

3300. R.M.A. SPECIFICATION FOR TESTING AND EXPRESSING THE OVER-ALL PERFORMANCE OF RADIO [Broadcast] RECEIVERS.—(*Journ. I.E.E.*, July 1937, Vol. 81, No. 487, pp. 104–111.) Followed by Introductory Remarks to the Discussion (S. Hill) and by the Discussion itself (pp. 114–122).

3301. DELAYED SWITCHING [for Gas-Filled Rectifiers: Defects of Thermal (Bimetallic) Method: Use of Relay worked by Hard Valve, with Indirectly Heated Cathode giving the required Thermal Delay].—P. D. Tyers. (*Wireless World*, 2nd July 1937, Vol. 41, pp. 7–8.)

3302. THE "MAG-NICKEL" FUSE [unaffected by Momentary Surges but giving Satisfactory Protection to Broadcast Receivers].—Belling & Lee Ltd. (*Wireless Engineer*, July 1937, Vol. 14, No. 166, p. 358.)

3303. AN IDEAL VALVE VOLTMETER [particularly for Servicing: No Batteries, No Meter to burn out (Cathode-Ray Tuning Indicator and 50-Kilohm Calibrated Variable Bias Resistor)].—Hygrade Sylvania Corporation. (*Wireless World*, 16th July 1937, Vol. 41, pp. 62–63.)

AERIALS AND AERIAL SYSTEMS

3304. THE APPLICATION OF TWO TYPES OF SOLUTION OF MAXWELL'S EQUATIONS TO THE CALCULATION OF THE ELECTROMAGNETIC FIELDS OF RADIATING CONDUCTORS.—J. Grosskopf. (*Hochf:tech. u. Elek:akus.*, June 1937, Vol. 49, No. 6, pp. 205–211.)

The two types of solution referred to are (1) that employing the retarded vector and scalar potentials of the currents and charges in the conductors, (2) that starting from Hertz's solution for an infinitely small radiating dipole and regarding the conductors as an aggregate of such elementary dipoles. Calculations are here given which show that "both methods lead to the same result in all cases, provided that the real physical phenomena are sufficiently taken into consideration." The first method is found to be "mathematically and physically clearer, so that it is to be preferred in all fundamental considerations and calculations." The second method proves to be "deducible from the first by certain differential operations and thus has really no separate existence as a fundamentally different method." Illustrations given are a linear conductor in free space (Fig. 4), a Beverage antenna (Fig. 5), and a single-wire aerial of length twice the wavelength, open and free from internal reflections (Fig. 6). For papers on the same subject *see* 2962 of August (Ghiron: Alford).

3305. THE FORMULAE FOR THE INDUCTION COEFFICIENTS OF EARTH LOOPS [Grounded Wires on or above Surface of Earth].—H. Buchholz. (*E.N.T.*, May 1937, Vol. 14, No. 5, pp. 180–195.)

For work already done on this subject *see* Foster, 1933 Abstracts, p. 624. Author's summary:—The known formulae for the inductance of earth loops, which is closely connected with the density distribution of earth currents, is, without further simplification, transformed [mathematically] in various ways, corresponding to various ratios of the parameters involved. Numerical evaluation thus becomes possible for the lower and medium orders of magnitude. In three limiting cases it is found that the results can be represented by known analytical formulae.

3306. "ANTENNENBUCH."—F. Bergtold. (At Patent Office Library, London: Cat. No. 77 604: 128 pp.)

3307. THE ELECTROMAGNETIC FIELD IN THE REGION OF VERY SHORT WAVES; SPONTANEOUS ROTATING FIELDS.—Krasny-Ergen. (*See* 3585.)

VALVES AND THERMIONICS

3308. ON THE ACTION OF A HOMOGENEOUS MAGNETIC FIELD ON THE MOTION OF ELECTRONS BETWEEN COAXIAL CYLINDRICAL ELECTRODES—G. Grünberg & V. Wolkenstein. (*Tech. Phys. of USSR*, No. 3, Vol. 4, 1937, pp. 179–199: in German.)

Both the methods previously employed (field distribution assumed—Hull: mathematical approximations—Awender, Thoma, & Tombs: Braude) allow the electron paths to be calculated approximately, but the errors involved have to be left undetermined until they can be found by comparison with strict solutions. Moreover, if it is desired to determine the characteristics of the tube (*e.g.* the connection between anode current and working conditions, particularly the value of the magnetic field), the first method gives practically no useful result, while to obtain sufficient accuracy by the second method approximation must be carried such a long way as to make the process of calculation extremely complicated. Thus Braude's approximation (1444 of 1936) converges by no means rapidly, so that even his third approximation, in spite of its complexity, gives a much worse picture of the electron paths (*see* p. 199) than Hull's solution.

The present writer sets out to obtain strict solutions of the various problems, which can be used for checking the accuracy of the various approximate methods and which give also a picture of the general relations within satisfactorily wide limits. He first shows that if the initial velocities of the electrons emerging from the cathode are neglected, the problem can be brought into a single-parametric form (eqn. 18) involving only the one parameter μ ($= H^2 r_k^{4/3}/I^{2/3}$). If the solution of this differential equation were known for all values of μ, the problem would be completely solved: but as no solution in analytical form has been arrived at, the writer has calculated a series of integral curves for various values of μ by the Adams-Störmer integration method, so choosing the values of μ that they apply to valves whose anode-radius/cathode-radius ratio lies between the limits 1 and 56.9 (originally 39.69, but *see* p. 196). From these curves the potential and density distributions can be calculated in relative units (sections 4 & 5) as well as the exact form of the electron paths (section 8). Also the transit time of the electrons through the condenser, and the related wavelength of the "electronic" oscillations, can be readily determined, the latter being seen to agree with Okabe's formula $\lambda = P/H_{crit.}$ It is found, however, that P is a function of μ, and of μ only, and varies from 17 840 to 20 200 according to the value of μ. These figures are much larger than those hitherto calculated (footnote to p. 194), though they agree with certain experimental results (*cf.* the 20 100 of Slutzkin & Steinberg—1929 Abstracts, p. 326).

3309. "ISLAND" FORMATION IN ELECTRONIC VALVES.—H. Bode. (*Zeitschr. f. tech. Phys.*, No. 7, Vol. 18, 1937, pp. 191–198.)

"The 'durchgriff' of a valve is approximately equal to the ratio of the anode/cathode capacity C_a to the control-electrode/cathode capacity C_g for cold electrodes. . . . This relation is based on the assumption that the emission current depends on the total displacement flux passing to the cathode in an electron-free field, but that the flux distribution on the cathode is without influence. If the emission density were proportional to the static (electron-free field) field strength acting on the cathode, the durchgriff would be constant and equal to the statically calculated value so long as the field strength at the cathode was everywhere negative—*i.e.* so long as the potential from the cathode outwards increased all over. But if the field strength becomes at any point positive, no emission current flows from there, if the initial velocity of the electrons is neglected. Since over the rest of the cathode the charge is greater than the total charge, the total emission current will be greater than that corresponding to the total charge; it follows, then, from eqn. 2 that an effective durchgriff D_w for the current must be reckoned with which is larger than the statically calculated value D_{st}. This is the recognised type of 'island formation.' In the following paper it will be shown, however, that other causes of 'island formation' exist. . . . An increase of durchgriff as a result of 'island formation' does not appear only as soon as regions of positive field strength occur at the cathode, but directly the static field distribution at the cathode becomes non-uniform. A third type of 'island formation' makes its appearance when, with non-uniform emission density at the cathode, saturation occurs at individual points (points of maximum static field strength). The emission-current density can nowhere on the cathode increase beyond a certain value; if this is reached at any point, then the total current will remain *below* the value corresponding to the cathode charge; from eqn. 2 it is seen that the durchgriff will therefore be decreased. . . . A decrease of durchgriff for high voltages on the anode and control electrode is clearly shown in triodes with open grid mesh and consequently large static durchgriff, such as the type RE604. The conditions are shown schematically in Fig. 2. In general, three types of surface F_1, F_2, and F_3 are found on the cathode. The F_1 surfaces are those which do not emit because of positive field strength: they are the 'islands.' The F_3 surfaces are those from which the saturation current is taken—'saturation surfaces.' The F_2 surfaces generally surround the F_3 surfaces; here a portion of the emitted electrons returns to the cathode as a result of space-charge action—they are the 'space-charge surfaces'."

Such increase of durchgriff by "island formation" is the more marked, the more non-uniform the static charge-distribution at the cathode: it is particularly great in valves whose electrode arrangement in itself gives a very inhomogeneous field at the cathode. Such a valve is the so-called "plate valve" with a filament stretched between two parallel plane electrodes, one serving as anode and the other as control electrode. The writer therefore concentrates on the calculation and experimental confirmation of the characteristics of such a valve, taking into account the three types of "island formation." Finally, in order to study the effect of space charge, whose action in such a valve differs considerably from its action in a valve with a control electrode between the anode and cathode, he takes steps to cut out "island formation" more or less completely, by using a cathode which is very thin compared with the space between the electrodes, and by mounting the cathode very exactly parallel to the plates: deviation from the parallel position leads to the same phenomenon of "island formation" as that produced by a thick cathode. Care must also be taken that the cathode is not longer than the other electrodes, that it does not emit outside these, and that there is no large potential drop along it.

3310. THE $T/2$-LAW FOR THE VARIATIONS OF UNSATURATED ELECTRON CURRENTS.—W. Schottky & E. Spenke. (*Naturwiss.*, 25th June 1937, Vol. 25, No. 26/27, p. 447.)

The writers refer to the work of Williams (1793 of 1936: for further development *see* 4069 of 1936) and Llewellyn (1930 Abstracts, pp. 279–280), and previous work of their own (1363 of April), on the relation between corpuscular and thermal variations in thermionic valves. They give new theoretical results on systems in thermal equilibrium and reach the general conclusion (shown in the figure) that "the shot effect, when weakened by space charge, is very nearly equal to but rather greater than the variation effect calculated on the basis of the $T/2$-law [T = temperature: *see* Williams, *loc. cit.*], taking into consideration the differential resistance of the distance within which space charge is effective." "The $T/2$-law perhaps gives a limit below which the true shot variations, weakened by space charge, never fall." The writers find however that their results confirm Llewellyn's fundamental idea (*loc. cit.*) that "thermal 'rustling' is somehow effective as a limit for the space-charge weakening of the shot effect."

3311. THE CAUSES OF NOISE IN AMPLIFIERS [and the Determination of e and the Boltzmann Constant].—M. Ziegler. (*Philips Tech. Review*, May 1937, Vol. 2, No. 5, pp. 136–141.)

3312. Shot Effect of Secondary Electron Currents from Nickel and Beryllium [measured at 110 kc/s: Data: Interpretation in Terms of Absorption and Scattering of Primary and Secondary Electrons within the Metal].—B. Kurrelmeyer & L. J. Hayner. (*Phys. Review*, 1st June 1937, Series 2, Vol. 51, No. 11, pp. 1007–1008: abstract only.) Extension of work referred to in 143 of 1936.

3313. Observations on Field Emission and Cathode Spraying of Thoriated Tungsten.—E. W. Müller. (*Zeitschr. f. Physik*, No. 1/2, Vol. 106, 1937, pp. 132–140.)

"Activation of wires containing ThO_2 and vaporisation from an external Th source both gave surfaces whose field emission depended largely on the degree of covering. The empirical ϕ^3 law already found [135 of January: *see* also 542 of February] for vaporised Ba cathodes was confirmed for the Th film. This could be uniformly dissipated by bombardment with argon, hydrogen, and nitrogen ions. Nitrogen ions were found to be adsorbed by the Th film but not on the pure W surface. Deactivation of the Th film by oxygen, known in thermionics, was also observed in these experiments. The work function of the impure cathodes rose to 6 ev. Observations on the roughening of W surfaces by cathode sputtering led to the conclusion that, with the cathodes employed, the 'fine' field strength [from points and ridges on the surface] responsible for the field emission was not much greater than the 'coarse' field strength calculated from the geometrical shape" [of the whole surface].

3314. Thin-Film Field Emission [Anomalous Secondary Electron Emission from Barium Borate Film].—E. R. Piore. (*Phys. Review*, 15th June 1937, Series 2, Vol. 51, No. 12, pp. 1111–1112.) For similar work with electrolytic aluminium-oxide films *see* 3419 of 1936 (Malter).

3315. Secondary Emission from Clean Tungsten [Measurements of Ratio of Secondary to Primary Current as Function of Primary Voltage, with Cold Target: Secondary Emission increases when Thorium is evaporated on to Clean Tungsten].—E. Coomes. (*Phys. Review*, 1st June 1937, Series 2, Vol. 51, No. 11, p. 1008: abstract only.)

3316. The Yield in the Ionisation of Potassium Atoms at Incandescent Platinum and Tungsten Surfaces [Measurements: Comparison with Results of Other Writers].—H. Mayer. (*Zeitschr. f. Physik*, No. 11/12, Vol. 105, 1937, pp. 725–733.) For other K/W results *see* E. Meyer, 1930 Abstracts, p. 279.

3317. Electric Field Influence on Surface Ionisation [of K and Na on Tungsten Surface].—L. N. Dobrezov. (*Physik. Zeitschr. der Sowjetunion*, No. 6, Vol. 11, 1937, pp. 647–659: in English.)

3318. The Kinetics of Adsorption with Interaction between the Adsorbed Particles [Theoretical Study: Expressions for Rates of Evaporation and Condensation: Properties of Hydrogen Film on Tungsten].—J. K. Roberts. (*Proc. Roy. Soc.*, Series A, 1st July 1937, Vol. 161, No. 904, pp. 141–153.)

3319. Thermionic Emission into Dielectric Liquids [Arguments against Reiss's Belief in the Potential Dissociation Theory: Impossibility of Measuring the True Photoelectric Work Function in Presence of a Liquid].—E. B. Baker & H. A. Boltz: Reiss. (*Phys. Review*, 1st June 1937, Series 2, Vol. 51, No. 11, p. 989.) *See* 2985 of August.

3320. Notes on the Wetting of Filaments by Molten Metals [Data on Filament Material desirable for evaporating Metal directly from Filament].—M. A. Countryman. (*Journ. of Applied Phys.* [formerly *Physics*], June 1937, Vol. 8, No. 6, pp. 432–433.)

3321. The Water-Cooled Pentode Types PA 12/15 at Ultra-Short Wavelengths [Theoretical Advantages of Pentode over Triode: Difficulties and Their Elimination: a Push-Pull Circuit for 6 m Waves].—K. Posthumus. (*Philips Transmitting News*, July 1937, Vol. 4, No. 3, pp. 1–12: in English and German concurrently.)

3322. High-Frequency Power Tubes [Water-Cooled Transmitting Triodes for Ultra-High Frequencies: Types 887 & 888, without Internal Insulating Material: Max. Output 200–1000 Watts].—RCA. (*Electronics*, July 1937, Vol. 10, No. 7, p. 58.)

3323. New Beam Power Transmitting Tubes [RK-47 and RK-48, Max. Anode Dissipation 50 and 100 Watts respectively].—(*QST*, July 1937, Vol. 21, No. 7, pp. 18 and 90.)

3324. Development and Manufacture of Modern Transmitting Valves.—H. G. Boumeester. (*Philips Transmitting News*, July 1937, Vol. 4, No. 3, pp. 15–24: in English and German concurrently.)

3325. Retarding Undesired [Secondary and "Back"] Emission in Vacuum Tubes.—B. H. Porter. (*Rad. Engineering*, June 1937, Vol. 17, No. 6, pp. 7–8.)

3326. Recent Tube Developments.—(*Rad. Engineering*, June 1937, Vol. 17, No. 6, pp. 13–15.)

3327. The Eddy Current Heating of Composite Cylindrical Systems [Theory of Adaptation of Eddy Current Heating to Production of Valves with Metal Envelopes: System of Cylindrical Tube containing Coaxial Cylinder: Application to Practical Systems: Experimental Confirmation].—D. A. Wright. (*Phil. Mag.*, July 1937, Series 7, Vol. 24, No. 159, pp 1–26.)

3328. Low-Drain Radiotrons suitable for "Air-Cell" Receivers.—(*Rad. Review of Australia*, April 1937, Vol. 5, No. 4, p. 99.)

3329. "Fundamentals of Vacuum Tubes" [Book Reviews].—A. V. Eastman. (*Wireless Engineer*, July 1937, Vol. 14, No. 166, p. 371: *P.O. Elec. Eng. Journ.*, July 1937, Vol. 30, Part 2, p. 156.)

3330. Another Tube Numbering System.—G. H. Gill. (*Rad. Engineering*, June 1937, Vol. 17, No. 6, pp. 22–23.)

3331. Glass for Modern Electric Lamps and Radio Valves.—Smelt. (*Philips Tech. Review*, March 1937, Vol. 2, No. 3, pp. 87–93.)

3332. Power Tube Characteristics [by use of Cathode-Ray-Tube Trace: Thyratron/Grid-Condenser Combination gives Short Pulses of Plate and Grid Currents: No Overheating of Valve Elements].—E. L. Chaffee. (*Electronics*, July 1937, Vol. 10, No. 7, p. 30.)

3333. The Theory of the Cosinusoidal Impulse.—A. I. Berg. (*Izvestiya Elektroprom. Slab. Toka*, No. 4, 1937, pp. 1–6.)

In designing a valve it is necessary to know the maximum value of the anode-current impulse. The existing methods are, however, insufficiently accurate, especially in the case of a valve operating with a peaked impulse. In the present paper a new method is proposed which is based on an investigation of the processes taking place in the grid circuit of the valve. An equation (7) of the family of the anode-current characteristics is given and a similar equation (6) is derived for the grid-current characteristics. From these two equations the relationship between the various constants of the grid and anode circuits are established and the main operating conditions of the valve determined, including the maximum value of a peaked impulse. The discussion is illustrated by a numerical example.

3334. A Universal Testing Set for Radio Valves.—D. Eringa. (*Philips Tech. Review*, Feb. 1937, Vol. 2, No. 2, pp. 57–63.)

3335. Erratum: A Simplified Harmonic Analysis.—Chaffee. (*Review Scient. Instr.*, July 1937, Vol. 8, No. 7, p. 227.) *See* 123 of January.

DIRECTIONAL WIRELESS

3336. Method of Radio Direction-Finding in Space [Increased Accuracy obtained by rotating Whole Receiver Polar Diagram round Axis making Small Angle with Direction of Maximum: Reception Intensity Constant and Independent of Rotation when Emitter is exactly in Direction of Axis of Rotation, with Circular Cross-Section of Receiver Polar Diagram].—W. Runge: Telefunken. (*Hochf:tech. u. Elek:akus.*, June 1937, Vol. 49, No. 6, p. 215: German Patent 641 096 of 28.1.34.)

3337. S.F.R. Radio-Guidance System for Aircraft (Patented).—Y. Rocard. (*Bull. de la S.F.R.*, Nos. 3 & 4, 10th Year, 3rd & 4th Quarters 1936, pp. 51–88 and 89–104: in French and English concurrently.)

As installed at Angoulême, Bussac, and Bordeaux. Among the many points discussed are the advantages of the phase-reversal method of keying (reversing the phase either in some stage of the transmitter or in the aerials themselves); the complex action when both reflectors are keyed together (as at Angoulême); and the observed phenomenon that sharp banking produces better reception. "One conceives that during this time certain rather long metal wire stays, being inclined towards the vertical, pick up a stronger radiation and reinforce the aerial by diffraction or capacitive coupling; so that horizontally polarised transmissions (where this effect would be utilised permanently) may very well be more advantageous, for communication with aircraft, than vertically polarised, in spite of the superiority of the latter as regards the fields produced at low altitudes."

3338. Aircraft Wireless [on the Air-Liner "Caledonia"].—(*Wireless World*, 16th July 1937, Vol. 41, p. 61.)

3339. Automatic Radio Navigation [Criticism of French Patent 786 890, Radio Navigational Instrument Corporation, U.S.A.].—(*Revue de l'Armée de l'Air*, April 1937, No. 93, pp. 473–480.)

3340. Aerodrome and Air Route Control [Survey, with Section on Future Development].—L. A. Sweny. (*Marconi Review*, March/April 1937, No. 65, pp. 9–19.)

3341. Blind Landing: the Lorenz-IT&T System at Indianapolis.—(*Electronics*, July 1937, Vol. 10, No. 7, pp. 26–27.) *See* also *Comm. & Broadcast Eng.*, June 1937, Vol. 4, No. 6, pp. 12–13 and 37.

3342. Proposed Blind Landing System [Micro-Wave Receivers distributed over Landing Field, Each starting Its Own Relay-Controlled Audio-Oscillator when excited by Highly Directional Beam from Aeroplane].—Sorensen. (*Aero Digest*, May 1937, Vol. 30, No. 5, p. 64.)

3343. Tube "repeats" Aircraft Compass Bearings [Sense and Magnitude of D.C. Output from Single-Valve Oscillator controlled by Position of Condenser Plate carried by Compass Needle: Output fed to Central-Zero Meter on Instrument Panel].—F. West. (*Electronics*, July 1937, Vol. 10, No. 7, p. 28.)

3344. The Acoustic Altimeter ["now ready to leave Research Laboratory"].—Delsasso. (*Science*, 28th May 1937, Vol. 85, Supp. pp. 10 and 12.)

ACOUSTICS AND AUDIO-FREQUENCIES

3345. Experiments on Room Acoustics [in connection with Concert and Lecture Halls: Necessity for Same Reverberation Duration (*not* Sabine Reverberation Time) at All Frequencies: Limitations of Fulfilment: Guiding Rules for Architects: etc.].—H. Stumpp. (*Zeitschr. V.D.I.*, 19th June 1937, Vol. 81, No. 25, pp. 720–721: summary only.) *See* also *Zeitschr. f. tech. Phys.*, No. 7, Vol. 18, 1937, p. 207.

3346. The Acoustic Effect of Distance and the Perception of Timbre in Radio Broadcasting.—I. G. Dreisen. (*Journ. of Tech. Phys.* [in Russian], No. 8, Vol. 7, 1937, pp. 861–866.)

If during a radio broadcast from a studio the microphone is moved, the listeners may become aware of the change in the distance between the microphone and the source of sound, and the timbre of the received sound may also become altered. These effects are attributed to the ability of the ear to discriminate between the two components of the sound energy in a studio, namely the direct sound and the reverberation sound. When the microphone is moved, the acoustic ratio (*i.e.* the ratio of the two components) is altered, and this may give rise to the effects mentioned. Some theoretical considerations supporting this view are presented, and the experimental data given by Rabinovich are discussed (1502 of 1935: *see* also 1492 of 1936.)

3347. "Panophonic" Sound demonstrated at I.R.E. [Australia] Meeting.—Raycophone Company. (*Rad. Review of Australia*, March 1937, Vol. 5, No. 3, p. 63.)

Embodying a vacuum-stabilised film drum giving "absolutely constant film speed"; a "cellular horn" unit (bank of logarithmic horns) for frequencies above about 250 c/s; etc. "Previous systems endeavoured to focus the light on to the light slit; the new idea is to focus an image of the sound track on to the light slit, and much more satisfactory reproduction resulted."

3348. The Playing Speed of Gramophone Records [Experiments on Listeners' Reactions to Incorrect Speeds].—J. de Boer. (*Philips Tech. Review*, Feb. 1937, Vol. 2, No. 2, p. 56.)

3349. Visual Tuning and Speed Control of a Phonograph Turntable [primarily for Use of Gramophone as Partner rather than Substitute for Actual Performing: Compound Stroboscopic Disc.].—V. Karapetoff. (*Review Scient. Instr.*, June 1937, Vol. 8, No. 6, pp. 213–214.)

3350. Public Address AVC [allowing for Movements of Head away from Microphone: Other Refinements of Modern PA Equipment].—H. Paro. (*Electronics*, July 1937, Vol. 10, No. 7, pp. 24–25.)

3351. Microphones [Survey of Special Types for Broadcasting, etc.].—A. Mainka. (*Zeitschr. V.D.I.*, 5th June 1937, Vol. 81, No. 23, pp. 657–660.)

3352. On the Design of a Moving-Coil Type Microphone with K.S. [Honda-Masumoto Magnetic Steel] Permanent Magnet.—Nukiyama & Horikawa. (*Jap. Journ. of Physics*, March 1937, Vol. 12, No. 1, Abstracts p. 26.)

3353. The Dielectric Constant of Mixed Crystals of Ammonium and Common Rochelle Salt.—Evans. (*See* 3428.)

3354. Energised Loudspeaker Magnets [Experimental Data on Three Designs].—N. W. McLachlan. (*Wireless Engineer*, July 1937, Vol. 14, No. 166, pp. 359–362.)

3355. General Solution of Rectangular Plates (Plane Problems) [Theory giving Stresses corresponding to Given Boundary Conditions].—L. Beschkine. (*Comptes Rendus*, 28th June 1937, Vol. 204, No. 26, pp. 1918–1920.)

3356. The Invention of the Telephone [particularly Reis's Share].—L. W. Taylor: G. W. O. H. (*Wireless Engineer*, July 1937, Vol. 14, No. 166, pp. 369–370.)

3357. Amplitude Limiting in the Aural Reception of Telegraphic Signals.—Dannehl & others. (*See* 3292.)

3358. Mixer Circuits: Part I.—A. Preisman. (*Comm. & Broadcasting Eng.*, June 1937, Vol. 4, No. 6, pp. 9–11 and 22.)

3359. Distortion in High-Fidelity Audio Amplifiers [Flat Characteristics do Not ensure Distortionless Reproduction: Common Fallacies: Suggested Safeguards in Design].—R. Lee. (*Rad. Engineering*, June 1937, Vol. 17, No. 6, pp. 16–18.)

3360. Note on Reduction of Distortion and Noise with Inverse Feedback [Disagreement with Carter's Statements].—J. R. Davey: Carter. (*QST*, July 1937, Vol. 21, No. 7, pp. 28–29.) *See* 2205 of June.

3361. Amplifier [and Audio-Frequency Transformer] Measuring Technique.—E. F. Kiernan. (*Electronics*, July 1937, Vol. 10, No. 7, pp. 18–20.)

3362. Formulae for the Calculation of the Theoretical Characteristics and Design of Coaxial Cables.—Jarvis & Fogg. (*See* 3396.)

3363. The Hammond Electric Organ [Description of Action, with Circuit Diagram].—(*Nature*, 19th June 1937, Vol. 139, pp. 1043–1044.)

3364. On the Theory of the Violin String.—Witt. (*Tech. Phys. of USSR*, No. 4, Vol. 4, 1937, pp. 261–288.) French version of the Russian paper referred to in 185 of January.

3365. The Resonoscope [5" Cathode-Ray Tube and Associated Circuits for tuning Musical Instruments and analysing Musical Tones in Instrument Manufacture].—L. B. Holmes. (*Electronics*, July 1937, Vol. 10, No. 7, pp. 17 and 66.)

3366. The Construction of "Search-Tone" [Exploring-Note] Analysers.—G. Weymann. (*Hochf:tech. u. Elek:akus.*, June 1937, Vol. 49, No. 6, pp. 181–183.)

The analyser here described dispenses with a push-pull rectifier and beat oscillator and uses a quartz resonator as a filter. The principles of search-tone analysers are first discussed, with special reference to the use of a push-pull modulator by Grützmacher (Fig. 1; 1930 Abstracts, p. 163) and others. The circuit proposed by the writer is shown in Fig. 2; it employs a longitudinally-oscillating quartz crystal.

3367. Contribution to the Theory and Technique of "Search-Tone" [Exploring-Note] Frequency Analysis.—K. Schoeps. (*Hochf:tech. u. Elek:akus.*, June 1937, Vol. 49, No. 6, pp. 184–194.)

The construction of a search-tone generator is described in Sec. A. The principles of frequency analysis using a search-tone are first discussed theoretically; calculations of the rectification and the "klirr" factor give the conditions for absence of error in the analysis. Considerations of the sensitivity for the fundamental low-frequency component show that the grid bias of the rectifier should be chosen in the region of negative grid voltage. The "pulling-into-tune" (Mitnahme) phenomenon also gives rise to a "klirr" factor (§ III); the circuit of the audio-frequency generator (Fig. 11) is designed so that the amplitude of the third harmonic is very small and "pulling-into-tune" is avoided. The underlying causes for the variation of the output voltage of the audio-frequency generator with frequency are theoretically analysed in § IV (circuit equivalent to oscillatory circuit, Fig. 13); it is found that the search-tone voltage can be made practically constant (Fig. 15) by proper adjustment of the resonance curve of the oscillatory circuit.

The method of analysis (Sec. C) in which this generator is employed works without a push-pull modulator. The resonator has hitherto been at the beginning of the audio-frequency band (group 1; Fig. 16) or above the highest frequency to be analysed (group 2; Fig. 17). In both these methods disturbance is caused, in a modulator without a push-pull circuit, by combination tones. In the new method here given, for analysis of frequencies up to 15 000 c/s, the resonator is just above 30 000 c/s and the search tone ranges from 15 000 to 30 000 c/s, so that the desired frequencies are recorded between 15 000 and 30 000 c/s, by using the summation tones. No interfering frequencies occur. The resolving power and rapidity of the various methods are discussed in Sec. D.

3368. The Valve as Variable Capacity, and Its Use as a "Howler" for Frequency Analysis, etc.—Engelhardt. (*See* 3258.)

3369. The Analysis of Noise in Electrical Machines [by Apparatus consisting of Thermal Bridge Modulator and Low-Pass Filter of Width 4 c/s: Errors due to Modulator Characteristic and Thermal Inertia: Examples of Noise Spectra].—W. Ernsthausen. (*Arch. f. Elektrot.*, 18th May 1937, Vol. 31, No. 5, pp. 299–311.)

3370. The Performance of Noise Meters in Terms of the Primary Standard [of "Equivalent Loudness" (Unit the British Standard Phon): Subjective (including a Two-Telephone Type) and Objective Noise Meters: Noises associated with Irregular Sound Fields: etc.]—B. G. Churcher & A. J. King. (*Journ. I.E.E.*, July 1937, Vol. 81, No. 487, pp. 57–81: Discussion pp. 81–90.)

3371. Modern Noise Meter ["Tannoy" Noise Meter manufactured in collaboration with N.P.L. for Tests on Motor Vehicles, etc.].—(*Wireless World*, 23rd July 1937, Vol. 41, pp. 84–85.)

3372. The Evolution of the Phon.—D. B. Foster. (*Wireless World*, 9th July 1937, Vol. 41, pp. 32–33.)

3373. Octaves and Decibels [Discussion, with Practical Data, showing Advantage of Logarithmic Units].—R. Vermeulen. (*Philips Tech. Review*, Feb. 1937, Vol. 2, No. 2, pp. 47–56.)

3374. Sound Waves and the Auditory Sensation [including New Idea of the Mechanism of Phonation].—R. Taguti. (*Jap. Journ. of Physics*, March 1937, Vol. 12, No. 1, Abstracts pp. 11–13.)

3375. On the Relation between the Performance and the Loudness of Sound of an Airscrew.—Obata & others. (*Jap. Journ. of Physics*, March 1937, Vol. 12, No. 1, Abstracts p. 11.)

3376. Supersonic Waves and Their Application in Science and Engineering.—L. Bergmann. (*Funktech. Monatshefte*, June & July 1937, Nos. 6 & 7, pp. 169–174 and 207–211.)

3377. The Acoustic Altimeter ["now ready to leave Research Laboratory"].—Delsasso. (*Science*, 28th May 1937, Vol. 85, Supp. pp. 10 and 12.)

3378. A New Method of Making Visible the Standing Supersonic Waves in Liquids.—O. Nomoto. (*Jap. Journ. of Physics*, March 1937, Vol. 12, No. 1, Abstracts pp. 10–11: in German.)

3379. The Velocities of Sound in Solutions and Their Relations to the Velocity of Sound of the Solute [Measurements for Organic Liquids by Supersonic Diffraction Method at Low and High Temperatures].—W. Schaaffs. (*Zeitschr. f. Physik*, No. 11/12, Vol. 105, 1937, pp. 658–675.)

3380. "Ultrasons et Biologie" [Book Review].—Dognon & Biancani. (*Alta Frequenza*, July 1937, Vol. 6, No. 7, p. 483.)

3381. On the Theory of the Diffraction of Light by Supersonic Waves.—van Cittert. (*See* 3392.)

PHOTOTELEGRAPHY AND TELEVISION

3382. THE PROGRESS IN TELEVISION [Recent Work of the Compagnie des Compteurs: Improvements in Disc Scanning at Transmitter: Interlaced Scanning (Ordinary and "Internal De-Phasing"): etc.].—R. Barthélémy. (*L'Onde Élec.*, June 1937, Vol. 16, No. 186, pp. 341–359.)

The introduction of electron multipliers has made available a 100- or 200-fold increase in gain: the distribution of this over various points of the system (*e.g.* a 4 : 1 reduction of the lighting, a 3 or 4 : 1 reduction of noise/modulation ratio, etc.) is described. The maximum number of lines successfully obtainable with a scanning disc is discussed: recent work has dealt with the third dimension of the holes, namely their depth (p. 345). Blocking of the holes by dust has been avoided, abroad, by enclosing disc and motor in a vacuum, but this is regarded as too elaborate: the writer's method is to clean the holes thoroughly and then to cover them with very thin and transparent cellophane, causing a 5% loss of light only. The success of a combination of mirror drum and fixed reflectors, giving a 400-line image, is mentioned in passing.

The problem of flicker leads to an examination of methods developed abroad of interlaced scanning. The "most practical" of these involves an odd number of lines to the image and demands an absolute constancy of phase and of fly-back time. "This condition hardly suits the very simple thyratron-controlled receivers which we use in France, and as a matter of fact even with other circuits the stability of interlacing is not assured" [though later the writer remarks that the control used in the London E.M.I. transmitter "gives more constant results"]. This difficulty has led to the development of the writer's "internal de-phasing" method of interlacing (pp. 355–356) using an even number of lines to the frame—which incidentally is an advantage for mechanical analysers—requiring hardly any change to the receivers, and giving interlaced-scanning images at the receiver with the stability usually associated with sequential scanning. However, "the theoretical superiority of interlacing needs to be proved in practice," and the writer mentions the difficulty of "stroboscopic effects" (*cf.* Bedford, 3042 of August). As regards film transmission, the writer's preference is for the method developed by himself and Monnot for 50-frame scanning of 25-images/sec. film, where each picture is transmitted twice (p. 349).

3383. TELEVISION SYSTEM WITH NIPKOW DISC [and Electron Multiplier: High-Pressure Mercury Lamp: 405 Lines, 25 Frames].—H. Rinia & C. Dorsman. (*Philips Tech. Review*, March 1937, Vol. 2, No. 3, pp. 72–76.)

3384. THE QUESTION OF THE GERMAN TELEVISION BROADCASTING STANDARDISATION [Comparison between 441-Line Interlaced Scanning and 50-Frame Sequential Scanning].—G. Weiss. (*Funktech. Monatshefte*, June 1937, No. 6, Supp. pp. 45–47.)

"To sum up, it may be said that in the present state of television technique in Germany the introduction of interlaced scanning with 441 lines is desirable. It is however pointed out that it seems not impossible that further developments may make the position once more favourable to ordinary scanning with 50 frame-changes. This [opinion] is based, above all, on the comparatively small difference in quality of the images transmitted by the two systems."

3385. STANDARDS IN TELEVISION [Comparison o RMA Proposed Standards with British Standards: Question of Transmitting the D.C. Component: Positive or Negative Modulation: etc.].—H. M. Lewis. (*Electronics*, July 1937, Vol. 10, No. 7, pp. 10–13 and 50, 51.)

3386. THE PROGRESS OF TELEVISION IN THE YEAR 1936 [in Europe and America].—(*Rev. Gén. de l'Élec.*, 19th June 1937, Vol. 41, No. 25, pp. 198–199D: summary only.)

3387. FOREIGN TELEVISION ACTIVITIES [including Russian].—(*Electronics*, July 1937, Vol. 10, No. 7, p. 36.)

3388. THE DEVELOPMENT OF TELEVISION [1931–1935].—Begrich. (*Funktech. Monatshefte*, June 1937, No. 6, Supp. pp. 47–50.) *See* 3050 of August: concluded in July issue.

3389. SCOPHONY TELEVISION SYSTEM: HIGH-DEFINITION PICTURES PROJECTED ON LARGE SCREENS [Special Demonstration].—(*Wireless World*, 23rd July 1937, Vol. 41, p. 78.)

3390. TELEVISION EXHIBITION AT THE SCIENCE MUSEUM [General Notes: Principle of Scophony "Supersonic Light Control Cell"].—(*Nature*, 19th June 1937, Vol. 139, p. 1077.) *See* also 3048/3049 of August.

3391. THE MODULATION OF LIGHT BY SUPERSONIC WAVES.—V. K. Kharizomenov. (*Journ. of Tech. Phys.* [in Russian], No. 8, Vol. 7, 1937, pp. 844–860.)

For previous work *see* 2302 of 1936. In the present paper the diffraction of light by a supersonic travelling wave is discussed theoretically, and this is followed by an account of experiments carried out to determine the relationship between the intensity of the diffraction spectra of various orders and the amplitude of the voltage applied to the crystal. A theoretical as well as an experimental investigation is also presented of the oscillations of a crystal in a liquid, and of their attenuation factor. The main conclusion reached is that this system has several advantages over a Kerr cell, of which the most important is that more light can be passed through the new modulator.

3392. ON THE THEORY OF THE DIFFRACTION OF LIGHT BY SUPERSONIC WAVES [System of Simultaneous Differential Equations derived, leading directly to Raman-Nath and Extermann-Wannier Solutions].—P. H. van Cittert. (*Physica*, July 1937, Vol. 4, No. 7, pp. 590–594: in German.)

3393. A Cathode-Ray Transmitting Tube [Iconoscope].—Krusser & Romanova. (*Izvestiya Elektroprom. Slab. Toka*, No. 4, 1937, pp. 20–23.)

Continuing the work referred to in 1863 of May, it is pointed out that no adequate description of the complex processes taking place in an iconoscope is available in the literature. In the present paper an attempt is made to give such a description, based on experience with iconoscopes over a period of 2 years.

3394. Commercial Background and Legal Aspects of Television.—J. N. Oppenheim. (*Electronics*, July 1937, Vol. 10, No. 7, p. 36: summary only.)

3395. High-Frequency Modulation of Ultra-Short Waves [Pure Amplitude Modulation (1.5–3 Mc/s) for Television by Use of Parallel-Wire Transmission Lines of Length $\lambda/4$ or Integral Multiple].—Banerjee & Singh. (*Indian Journ. of Phys.*, May 1937, Vol. 11, Part 2, pp. 91–98.) For a preliminary report *see* 483 of February.

3396. Formulae for the Calculation of the Theoretical Characteristics and Design of Coaxial Cables [including Cases when Phase Delay is to be taken into account as well as Attenuation: Advantages of Thin-Wall Conductors].—R. F. J. Jarvis & G. H. Fogg. (*P.O. Elec. Eng. Journ.*, July 1937, Vol. 30, Part 2, pp. 138–151.)

3397. Modern Developments in Television: Part II—Reception Systems.—S. T. Stevens. (*P.O. Elec. Eng. Journ.*, July 1937, Vol. 30, Part 2, pp. 129–137.) For Part I *see* 2262 of June.

3398. A Television Receiver [for 240-Line Sequential and 405-Line Interlaced Transmissions].—C. L. Richards. (*Philips Tech. Review*, Feb. 1937, Vol. 2, No. 2, pp. 33–38.)

3399. The Wireless World Television Receiver.—W. T. Cocking. (*Wireless World*, 2nd, 9th, 16th & 23rd July, 1937, Vol. 41, pp. 2–6, 24–27, 46–49, & 68–72.)

3400. Investigations on Selenium Photocells [Systematic Examination of Mass-Produced SAF Cells Types C and D: Ageing by Continuous Illumination: Variation of Photo-effect with Temperature: Change of Photocurrent when Total Illumination is kept Constant but Density is Varied].—L. Bergmann & R. Pelz. (*Zeitschr. f. tech. Phys.*, No. 7, Vol. 18, 1937, pp. 177–191.)

3401. Secondary-Emission Photocell [Osram C.W.S.24].—General Electric Company. (*Journ. Scient. Instr.*, July 1937, Vol. 14, No. 7, pp. 250–251.) The cell referred to in 3069 of August.

3402. Absorption of Gamma Rays measured by their Photo-Effect in Beryllium.—J. Rotblat. (*Nature*, 5th June 1937, Vol. 139, pp. 963–964.)

3403. On the Preliminary Discharge and the Spark Voltage [Relation between Photoelectric Effect and Spark Voltage: etc.].—R. Kobayashi. (*Electrotech. Journal*, Tokyo, July 1937, Vol. 1, No. 2, pp. 68–69.) The experimental results give a relation which, "from the standpoint of the theory of photoelectric effect concerning sparking mechanism, is quite contrary to its expectation."

3404. Investigations on the Long-Wave "Tail" of the Natural Ultra-Violet Absorption of Alkali Halide Crystals [Long-Wave "Tail" is a Single Absorption Band: Effect increased by Various Treatments of Crystal: Long-Wave Absorption due to Natural Constituents of Crystal in Disturbed Position]: *and* Thermal Treatment and Diffusion in Salt Crystals [Effect of Diffusion of Foreign Materials in Crystal].—E. Rexer. (*Zeitschr. f. Physik*, No. 1/2, Vol. 106, 1937, pp. 70–92: pp. 93–101.)

3405. The Production and Mobility of Colour Centres in Alkali Halide Crystals, *and* Other Papers on these Crystals.—Rögener, Mollwo, Hilsch, Honrath, Hohls. (*Ann. der Physik*, No. 5, Vol. 29, 1937, Series 5, pp. 386–448.)

3406. The Preparation of Monocrystalline Layers of Silver Haloids.—Levitskaya & Korolev. (*Journ. of Tech. Phys.* [in Russian], No. 7, Vol. 7, 1937, pp. 760–761.)

3407. Coloration of Zirconium Silicate by Irradiation [with Ultra-Violet Light: Effect similar to that with Alkali Halides: Effect of Increasing Temperature: Absorption Bands].—J. Lietz. (*Naturwiss.*, 11th June 1937, Vol. 25, No. 24/25, pp. 415–416.)

3408. The Luminous Efficiency of the Positive Column of a Discharge in Sodium Vapour.—Klarfeld & Taraskov. (*Journ. of Tech. Phys.* [in Russian], No. 8, Vol. 7, 1937, pp. 836–843.) For a previous paper *see* 623 of February.

3409. Progress in Light and Illumination Technique in 1936.—(*Elektrot. u. Maschbau*, 27th June 1937, Vol. 55, No. 26, Supp. pp. 1–7.)

MEASUREMENTS AND STANDARDS

3410. Investigations on Transversely-Vibrating Quartz Plates.—R. O. Schumacher. (*Telefunken* [formerly *Telefunken-Zeitung*], July 1937, Vol. 18, No. 76, pp. 16–21.)

For the wave-range 30–1000 m, "thickness" oscillations (frequency dependent on the dimension between the electrodes) may be used, but even between 800 and 1000 m it becomes difficult to preserve the ratio of diameter to thickness (which should never fall short of 10 : 1 for round plates) because of the large diameters to which this leads. Above 1000 m, therefore, transverse oscillations are used, for which the "wave-coefficient" ranges from 80 to 120, thus leading to reasonable diameters.

The present investigation deals with such transverse oscillations in round and square "Y-cut" plates, using two ways of determining the vibration patterns: the optical interference method and the lycopodium-powder method. The former shows only the motion centres on the surface, while the latter also gives the nodes and antinodes at the edges of the plate. Since low temperature coefficients are of practical importance, only the oscillations having the smaller of the two frequencies given by such plates are dealt with, since these oscillations have been shown by Bechmann to have two orientation points yielding a zero coefficient.

The investigations show the dependence of the oscillation patterns on the shape of the edges of the plate (such as the angle at which they are bevelled), since on this depends the reflection of the fundamental vibration at the limiting surfaces. This leads to a discussion of the special Telefunken low-damping mounting, in which "stalks" are provided at opposite nodal points on the round plate, cut out of the same piece as the plate in directions perpendicular to the electrical axis. These "stalks" take no part in the mechanical vibration and can thus be used for fixing the plate. If cut *parallel* to the electrical axis (Fig. 30) they are no longer free from taking part in the vibration, and are less effective. A final section deals with the bad effects of unsuitable methods of mounting: the pressure should always be along a nodal line (Fig. 35): if it is slightly slanting the pattern is distorted (Fig. 36) and the damping increases. If the pressure is applied at right angles to the nodal lines the pattern is completely changed (Fig. 37) and the damping becomes very severe.

3411. QUARTZ RESONATORS: QUARTZ FILTERS.—Bechmann: Kautter. (*See* 3283 & 3284.)

3412. A "SCHLIEREN" EXPERIMENT ON THE VIBRATION FORM OF A THIN QUARTZ DISC [with Photographs of Vibration Forms].—W. Schaaffs. (*Zeitschr. f. Physik*, No. 9/10, Vol. 105, 1937, pp. 576–578.)

3413. TRANSFORMATION FROM α- TO β-QUARTZ [studied by Variation of Double Refraction and Temperature with Time].—H. E. von Steinwehr. (*Naturwiss.*, 28th May 1937, Vol. 25, No. 22, p. 348.)

3414. A NEW METHOD OF MEASUREMENT OF THE PIEZOELECTRIC EFFECT FOR CRYSTALLINE POWDERS.—J. Engl & I. P. Leventer. (*Ann. der Physik*, Series 5, No. 5, Vol. 29, 1937, pp. 369–385.)

The principle of the method is that a mixture of the crystalline powder and benzol is used as the dielectric in a measuring condenser designed as a calorimeter (Fig. 2). The power absorbed at high frequencies is measured as a function of the wavelength (Figs. 4, 6); the piezoelectric part has the character of a resonance curve (dielectric losses are shown in Figs. 5, 7). The theory of the method is given; Fig. 1 shows the circuit used. The method is shown to be applicable to the quantitative comparison of various types of crystal.

3415. THE PIEZODIELECTRIC EFFECT AND ELECTROSTRICTION IN ANISOTROPIC OR ISOTROPIC MEDIA [Phenomenological Theory].—H. Osterberg & J. W. Cookson. (*Phys. Review*, 15th June 1937, Series 2, Vol. 51, No. 12, pp. 1096–1101.)

3416. THE VARIATION OF THE MODULUS OF ELASTICITY AND THE ATTENUATION OF TRANSVERSELY OSCILLATING METALLIC RODS WITH THE AMPLITUDE [Experimental Curves for Ferromagnetic Materials: Connection with Magnetostriction].—F. Förster & W. Köster. (*Naturwiss.*, 25th June 1937, Vol. 25, No. 26/27, pp. 436–439.)

3417. ON THE LINEAR INTERPOLATION OF FREQUENCY CORRECTIONS IN THE RE-CALIBRATION OF WAVEMETERS.—I. B. Selyutin. (*Izvestiya Elektroprom. Slab. Toka*, No. 4, 1937, pp. 17–19.)

In re-calibrating wavemeters it is usual to check a few points and find the intermediate points by calculation. In the present paper a method is proposed for the linear interpolation of the correcting factor, thus avoiding the necessity of calculating the calibration table.

3418. TIME DETERMINATION AND TIME BROADCAST [Historical Survey: Description of Automatic Time Broadcaster].—J. F. Hellweg. (*Journ. Franklin Inst.*, May 1937, Vol. 223, No. 5, pp. 549–563.)

3419. ON MEASUREMENTS OF THE LOAD ON A TWO-WIRE LINE BY THE METHOD OF ROOSENSTEIN-TATARINOV AT ULTRA-HIGH FREQUENCIES [Wavelengths round 3–4 m].—N. N. Malov. (*Physik. Zeitschr. der Sowjetunion*, No. 5, Vol. 11, 1937, pp. 539–544: in German.)

In their electro-medical researches the writers require to measure the load introduced by the insertion of an object into the condenser of the r.f. circuit. The air gaps between the object and the condenser plates render the equivalent resistance of the former only small; this resistance cannot be measured by Drude's method because those parts of the object which are not actually inside the condenser affect the Lecher system and spoil the results. The writers therefore employ the method developed by Roosenstein and by Tatarinov (1931 Abstracts, pp. 36 & 269 respectively), in which the condenser, with the object inside it, is connected across the end of the two-wire line, the other end of which is loosely coupled to a r.f. generator. The potential distribution is determined with an indicator (Fig. 3) very loosely coupled to the line (preferably to both branches, since Tatarinov has shown that small accidental asymmetries in the excitation of the line are then unimportant), and the required resistance is given, by eqns. 2 and 3, from the distance y_0 (between the potential node and the end of the line which is closed by the condenser) and the ratio k of the potentials at the nodes and antinodes. The influence of the indicator is analysed: this is small in the neighbourhood of a potential node, and it is therefore disadvantageous to make measurements near an antinode (the writer states that Belyakova—276 of January—

neglected this point and probably falsified his results accordingly). The ratio *k* is therefore found indirectly from the values of potential measured at the potential node and at a spot quite close to it (bottom of p. 541); or, in cases where the value at the node is too small to measure accurately, from the values measured at two points at small distances z_1, z_2 from the node (top of p. 542). The coupling of the indicator to the two branches of the line is through the capacity between the lower ends of the line hooks zz (Fig. 3) and the ends of the fine wires from the detector circuit, passing up the capillary glass tubes KK.

3420. Statical Measurement of Maximum Voltages of All Frequencies.—H. Döring: O. Lintner. (*Hochf:tech. u. Elek:akus.*, June 1937, Vol. 49, No. 6, p. 214.) Döring remarks that Lintner's method (656 of February) is not valid at ultra-high frequencies.

3421. A Mains-Driven Dynatron R.F. Damping Meter as a Practical Instrument [for Wavelengths down to 30 m].—A. Peetz. (*Hochf:tech. u. Elek:akus.*, June 1937, Vol. 49, No. 6, pp. 212–214.)

The resonance resistance of the circuit to be measured is balanced against a negative resistance (dynatron circuit Fig. 1). The measurement of the negative resistance is discussed in § I; a compensation method is used, for which a compensation voltage is derived as shown in Fig. 3. The whole circuit of the meter is given in Fig. 4, which shows the devices for keeping filament and screen-grid voltage constant (§ II). The resonance resistance can be read directly off a curve, while the decrement, self-induction, and capacity of the circuit can also be determined with a little calculation.

3422. The Occurrence and Measurement of Sideband Asymmetry (Phase Modulation).—Hofer. (*See* 3276.)

3423. A Method of Measurement of the Complex Transmission Constants of Amplifiers.—A. Agricola. (*E.N.T.*, May 1937, Vol. 14, No. 5, pp. 162–167.)

This method is a development of a known principle of phase-distortion measurement (Nyquist & Brand, 1931 Abstracts, p. 44). Fig. 2 shows the circuit; it is fundamentally the same as the three-voltmeter method of Wright & Graham (2715 of 1936) and can be used up to arbitrarily high frequencies. The method of working is described; Figs. 4, 5 illustrate the derivation of phase- and transit-time-curves of wide-band amplifiers for high-frequency cables. The possible sources of error are investigated (Fig. 6); the accuracy can be increased by using only small differences between input and output voltages. "If the ratio of the difference to the input voltage rises to the value $\sqrt{2}$ when the measuring frequency is changed, an additional phase displacement of 180° must be introduced."

3424. On the Measurement of Field Strengths at High Frequencies.—S. Ya. Braude. (*Journ. of Tech. Phys.* [in Russian], No. 7, Vol. 7, 1937, p. 763.)

Replying to Malov's letter dealt with in 1080 of March, the writer states that the error due to heat losses in the glass bulb was taken into account in his experiments. Further, he does not agree with Malov's suggestion that the heating of the bulb could be used for the direct measurement of electric field strengths.

3425. Graphical Determination of the Electrical Conditions [Voltages: Field Strengths] in Coaxial Cylinders with Stratified Dielectric.—H. Ziegler. (*Arch. f. Elektrot.*, 18th May 1937, Vol. 31, No. 5, pp. 333–337.)

3426. Schering Bridge Equipment for Dielectric Loss Measurements on Installed Apparatus.—Dannatt & Edwards. (*Met.-Vickers Gazette*, July 1937, Vol. 17, No. 291, pp. 11–13.)

3427. Free Intra-Molecular Rotatory Power and Dielectric Losses in a High-Frequency Field [shown by Measurements on Organic Liquids with Wavelength 7.2 m, where Reciprocal of Frequency is Intermediate between Relaxation Times of Whole Molecule and of Freely Rotatable Polar Group within It].—L. D'Or & J. Henrion. (*Physik. Zeitschr.*, 1st June 1937, Vol. 38, No. 11, p. 426.)

3428. The Dielectric Constant of Mixed Crystals of Sodium Ammonium and Sodium Potassium Tartrates [Ammonium and Common Rochelle Salt: Measurements over Frequency Range 50–2000 kc/s: Rapid Fall of Dielectric Constant with Increased Proportion of Ammonium Salt].—R. C. Evans. (*Phil. Mag.*, July 1937, Series 7, Vol. 24, No. 159, pp. 70–79.)

3429. An Absolute Method for measuring the Dielectric Constants of Fluids and Solids at Ultra-High Frequencies [Modified Drude (Lecher-Wire) Method using Only Thin Slab of Material: Mathematical Formulae: Experimental Technique].—R. King. (*Review Scient. Instr.*, June 1937, Vol. 8, No. 6, pp. 201–209.) Another application of the technique described in an earlier paper (3593 of 1935).

3430. Dielectric Constants of Solutions of Some Alcohols in Benzol [at Wavelength of 57.75 cm].—Romanov & Eltzin. (*Physik. Zeitschr. der Sowjetunion*, No. 5, Vol. 11, 1937, pp. 526–538: in German.)

3431. A 60 to 100 Megacycle Oscillator [with Fixed Condenser and Tuning by "Split-Rivet" Connection to Bare-Wire Coils].—A. Binneweg, Jr. (*Electronics*, July 1937, Vol. 10, No. 7, p. 29.) For the writer's 20–60 Mc/s oscillator *see* 1489 of April.

3432. A Rochelle Salt Electrometer [for High-Impedance Circuits: using a Brush "Bimorph" Crystal].—M. J. E. Golay. (*Review Scient. Instr.*, July 1937, Vol. 8, No. 7, pp. 228–230.)

3433. An Ideal Valve Voltmeter.—(*See* 3303.)

3434. A New Load-Meter [for Transformer Loads: Circuits applicable to Voltage and Current Transformers].—W. Hohle. (*Physik. Zeitschr.*, 1st June 1937, Vol. 38, No. 11, pp. 389–394.)

3435. Mutual Inductance Calculations [Simplified Method for Coaxial Single-Layer Coils]. —D. Pollack. (*Electronics*, July 1937, Vol. 10, No. 7, pp. 31–32.)

3436. Slide-Rule Impedance Calculations [avoiding Addition, by Use of "3–4–5" Triangle Method].—Gunsolley. (*Electronics*, May 1937, Vol. 10, No. 5, pp. 45–46.) For correspondence and alternative methods see *ibid.*, July 1937, No. 7, pp. 34 and 46, 64.

3437. "Elektrische Messtechnik" [I—Direct-Current Measuring Technique: Book Review].—Schwerdtfeger. (*Zeitschr. f. tech. Phys.*, No. 7, Vol. 18, 1937, p. 204.)

SUBSIDIARY APPARATUS AND MATERIALS

3438. Production of Electron-Optical Structure Images with Photoelectrons.—Gross & Seitz. (*Zeitschr. f. Physik*, No. 11/12, Vol. 105, 1937, pp. 734–737.)

The images referred to are electron pictures of the crystalline structure of metals. Images of gas-charged nickel surfaces are shown in Fig. 2. The method here proposed of obtaining reproducible pictures easily is to cover the crystalline surfaces with very thin, photoelectrically active films of different thickness. Fig. 3 shows emission pictures of a nickel surface covered with a vaporised barium film (*see* also Brüche, 1021 of 1936). The procedure finally adopted was to vaporise barium on to the metal surface after degassing it, heat it to a high temperature and cool it again; a photoelectric structure image was then obtained (Figs. 4, 5) which showed the good contrast obtained with thermionic images at high temperatures. The pictures in Figs. 4, 5 are also unaffected by scattered light reflected from the cathode.

3439. An Economical Cathode-Ray Oscillograph Design using the Type 913 "Midget" Tube.—(*Rad. Review of Australia*, April 1937, Vol. 5, No. 4, pp. 89–92.)

3440. Automatic Plotting of Electron Trajectories [Description of Apparatus: Circuit Diagram: Methods of accounting for Initial Velocity, Transverse Magnetic Fields, Relativistic Change of Mass: Data illustrating Precision].—Langmuir. (*Nature*, 19th June 1937, Vol. 139, pp. 1066–1067). The basic principle of the system is the same as that referred to in 1958 of May (Gabor).

3441. Calculation of the Influence of Space Charge in Electron Optics [General Theory with Indication of Method for Trajectory Calculation].—Cotte. (*Comptes Rendus*, 28th June 1937, Vol. 204, No. 26, pp. 1933–1935.)

3442. On the Action of a Homogeneous Magnetic Field on the Motion of Electrons between Coaxial Cylindrical Electrodes.—Grünberg & Wolkenstein. (*See* 3308.)

3443. The Focusing of Electrons in an X-Ray Tube [from a Helical Filament within a Focal Cup].—Beese. (*Review Scient. Instr.*, July 1937, Vol. 8, No. 7, pp. 258–262.) With the theory of the variations of focal-spot patterns caused by changes in the geometry of the cathode structure.

3444. Electrical and Luminescence Properties of Willemite Screen Material [Measurements of Surface Potential, Resistivity, and Luminous Output of Fluorescent Screen].—Nottingham. (*Phys. Review*, 1st June 1937, Series 2, Vol. 51, No. 11, p. 1008: abstract only.)

3445. The Recording of Rapidly Occurring Electric Phenomena with the Aid of the Cathode-Ray Tube and the Camera. —Custers. (*Philips Tech. Review*, May 1937, Vol. 2, No. 5, pp. 148–155.)

3446. "Kipp Generators" with High-Vacuum Valves.—Faust. (*See* 3264.)

3447. "Die praktische Verwendung des Elektronenstrahloszillographen" [Book Review].—Klein. (*Elektrot. u. Masch:bau*, 20th June 1937, Vol. 55, No. 25, p. 307.) Based on Leybold-von Ardenne apparatus.

3448. Structural Investigations of Roughness and Granule Size [of Silver Films of Various Thickness on Various Substrata, and of Organic Materials] by Means of Electron Interference Patterns.—Papsdorf. (*Ann. der Physik*, Series 5, No. 6, Vol. 28, 1937, pp. 555–568.)

3449. The Structure of Thin Metallic Films condensed at Low Temperatures [Electron Diffraction Photographs show Growth of Crystals with Increasing Temperature of Ag & Sb Films].—Hass. (*Naturwiss.*, 9th April 1937, Vol. 25, No. 15, pp. 232–233.)

3450. The Construction and Operation of a Cyclotron to produce One Million Volt Deuterons.—Kruger & Green. (*Phys. Review*, 1st May 1937, Series 2, Vol. 51, No. 9, pp. 699–705.) Details of apparatus referred to in 1549 of April.

3451. Gaseous-Current High Tension Generators [Spherical Glass Particles carried by Air Current in Endless Path passing through Ioniser].—Pauthenier & Moreau-Hanot. (*Journ. de Phys. et le Radium*, May 1937, Series 7, Vol. 8, No. 5, pp. 193–196.)

3452. High-Voltage Generator in the Greinacher Connection [using Mulder's Special Oxide-Cathode Mercury-Vapour Rectifier Tube with Multi-Sectional Tube, Condenser-Linked, along Discharge Path].—Gradstein: Mulder. (*E.T.Z.*, 24th June 1937, Vol. 58, No. 25, p. 694: summary only.)

3453. The Corona Attenuation of Surges [Formula giving, for Known Wave Form, the Length of Run of the Over-Voltage Wave after It has dropped to the Initial Corona Voltage].—Strigel. (*Arch. f. Elektrot.*, 18th May 1937, Vol. 31, No. 5, pp. 338–342.)

3454. The Discharge Mechanism in the "Siemens" Ozone Tube [Current consists of Sinusoidal Dark Current with Strong Pulses caused by Spark Discharge].—Klemenc, Hintenberger, & Höfer. (*Naturwiss.*, 16th April 1937, Vol. 25, No. 16, p. 249.)

3455. Contribution to the Question of the Influence of Arrangement and Polarity on the Breakdown Voltage with Spark-Gaps between Spheres with One Pole Earthed.—Dattan. (*Arch. f. Elektrot.*, 18th May 1937, Vol. 31, No. 5, pp. 342–347.)

3456. Space-Charge- or Ion- Breakdown? [Breakdown Onset due to Ionising Action of Positive Ions: Theory and Properties of Space-Charge Breakdown: Field Distortion: etc.].—Rogowski & Wallraff. (*Zeitschr. f. Physik*, No. 3/4, Vol. 106, 1937, pp. 212–229.) *See* also *Naturwiss.*, 25th June 1937, Vol. 25, No. 26/27, p. 448 (Rogowski).

3457. The Question of the Variation of Sparking Delay with Voltage [Calculations, based on Townsend's Theory, of Probability that One Electron emitted from Cathode causes Striking of Gas Discharge].—Hertz. (*Zeitschr. f. Physik*, No. 1/2, Vol. 106, 1937, pp. 102–107.)

3458. The Characteristic of the Townsend Current and the Effect of Irradiation on the Striking Voltage of a Glow Discharge.—Schade. (*Zeitschr. f. Physik*, No. 9/10, Vol. 105, 1937, pp. 595–619.)

"Theoretical and experimental investigation of the effect of the space charges occurring in a discharge with very small current density between parallel plane electrodes. Results:—The initial characteristic (Townsend current characteristic) descends linearly. On irradiation of the cathode, the glow discharge strikes at a voltage below that of normal striking and at a definite current density. Both the diminution of striking voltage and the striking current density are proportional to the square root of the current density of the photo-current due to irradiation. Rogowski's view [346 of January] is confirmed for low pressures."

3459. Determination of the Townsend Ionisation Coefficient α for Mixtures of Neon and Argon, *and* The Townsend Ionisation Coefficient α and Some Elementary Processes in Neon with Small Admixtures of Argon.—Kruithof & Penning: Kruithof & Druyvesteyn. (*Physica*, June 1937, Vol. 4, No. 6, pp. 430–449: pp. 450–463: both in English.)

3460. The Mobility of Electrons in Neon.—Druyvesteyn. (*Physica*, June 1937, Vol. 4, No. 6, pp. 464–466: in English.)

3461. Statistics of Space Charges in Brush Discharges [Gleitfunken]: Part I—Investigations of the Elementary Processes leading to Knowledge of the Most Probable Distribution [Theory on Hypothesis of Superficial Plasma: Potential Distribution on Dielectric Surface].—Müller-Strobel. (*Arch. f. Elektrot.*, 22nd April 1937, Vol. 31, No. 4, pp. 233–253.)

3462. Decrease of Breakdown Voltage [of Spark Gap] at High Frequencies [between 10^4 and 10^5 c/s is due to Collection of Positive Ions and Consequent Space Charge and Field Distortion: Calculations including Effect of Diffusion: Equations for Voltage Decrease in Terms of Frequency].—Böcker. (*Arch. f. Elektrot.*, 22nd March 1937, Vol. 31, No. 3, pp. 166–179.)

3463. The Connection between Distribution of Emission and Conduction of Heat [from Cathode Region] in the Luminous Arc, with Some Observations on the Emission in the Spark Discharge [with Remarks on Mechanism of Electron Emission from Cathode, and Related Questions].—Schmidt. (*Zeitschr. f. Physik*, No. 1/2, Vol. 106, 1937, pp. 35–48.)

3464. The Application of Paschen's Law to the Reignition of an Arc [of "Thermionic" and "Field Emission" Types: Relation between Reignition Potential and Product of Pressure and Spacing, analogous to Paschen's Law for Initial Sparking Potential].—Power & Cobine. (*Journ. of Applied Phys.* [formerly *Physics*], April 1937, Vol. 8, No. 4, pp. 287–290.)

3465. Potentials in the Intermittent Glow Discharge [General Experimental Properties].—Bockstahler & Ritow. (*Phys. Review*, 1st June 1937, Series 2, Vol. 51, No. 11, p. 1009: abstract only.)

3466. A New Effect with the Glow Discharge in Argon [with Cylindrical Anode surrounding Two Circular Disc Cathodes: Larger Part of Glow Discharge Current comes from Cathode with Smaller Voltage relative to Anode: Explanation by Differential Ionisation of Electrons in Argon].—Geiger. (*Zeitschr. f. Physik*, No. 1/2, Vol. 106, 1937, pp. 17–34.)

3467. Discussion on "Applications of the Hot-Cathode Grid-Controlled Rectifier, or Thyratron."—Whiteley. (*Journ. I.E.E.*, July 1937, Vol. 81, No. 487, pp. 137–138.) *See* 2795 of 1936.

3468. Physical Principles of Gas-Filled Hot-Cathode Rectifiers.—Druyvesteyn & Mulder. (*Philips Tech. Review*, April 1937 Vol. 2, No. 4, pp. 122–128.)

3469. Remarks on a Paper by Engel & Steenbeck [on the Mean Free Path of the Electrons in a Mercury-Vapour Plasma].—Klarfeld: Engel & Steenbeck. (*Physik. Zeitschr. der Sowjetunion*, No. 6, Vol. 11, 1937, pp. 669–671: in German.) Attributing the results (which depart from previously established ideas on gaseous discharges) to causes arising from the experimental technique.

3470. Recombination in the Afterglow of a Discharge [Measured Value of Recombination Coefficient with Thermionic Discharge in Cs Vapour and with Mercury Arc].—Mohler. (*Phys. Review*, 1st June 1937, Series 2, Vol. 51, No. 11, pp. 1008–1009: abstract only.)

3471. The Positive Column and Its Relation to Design Calculations in Mercury-Arc Rectifiers.—White. (*Tech. Phys. of USSR*, No. 2, Vol. 4, 1937, pp. 138–154: in English.)

3472. The Effect of the Addition of Potassium on the Gradient of the Positive Column of the Mercury Arc.—Purcaru. (*Bull. de Math. et de Phys. de l'Éc. Polytech. Roi Carol II*, Bucarest, Fasc. 19, 20, 21, 1937, pp. 45–51: in French.)

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3477. The Effect of Heat on the Unipolar Electrical Conductivity of Carborundum [Measured Behaviour of Conductivity interpreted on Wilson–Fowler Electron Theory of Semiconductors].—Chakravarty & Khastgir. (*Phil. Mag.*, July 1937, Series 7, Vol. 24, No. 159, pp. 127–141.)

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3479. A Simple Counting Circuit [Triode and Neon Lamp].—Fertel. (*Journ. Scient. Instr.*, April 1937, Vol. 14, No. 4, pp. 142–143.)

3480. The Application of the Gaseous Discharge Tube to Problems of Voltage Regulation [Method using Inexpensive Neon Tubes, combined with Barretters].—Morton. (*Journ. Scient. Instr.*, May 1937, Vol. 14, No. 5, pp. 161–164.)

3481. Voltage Regulators using Magnetic Saturation [Survey].—Way. (*Electronics*, July 1937, Vol. 10, No. 7, pp. 14–16.)

3482. "The Lead Storage Battery" [Book Review].—Brown. (*Wireless Engineer*, July 1937, Vol. 14, No. 166, p. 371.)

3483. Primary Batteries [Dry and Wet] according to Recent Patents.—Jumau. (*Rev. Gén. de l'Élec.*, 22nd May 1937, Vol. 41, No. 21, pp. 657–665.)

3484. American Standard Specification for Dry Cells and Batteries.—(*Circular C 414 of National Bureau of Standards*, 1st March 1937: 11 pp.)

3485. Electrical and Mechanical Ageing of Copper Conductors under the Prolonged Action of Electric Current [Slight Lowering of Mechanical Resistance and Increase of Electrical Conductivity].—Yadoff. (*Comptes Rendus*, 7th June 1937, Vol. 204, No. 23, pp. 1715–1717.)

3486. Rational Wire Tables [Resistances and Number of Turns in Given Space, for Covered Wires].—Cosens. (*Journ. Scient. Instr.*, April 1937, Vol. 14, No. 4, pp. 122–126.)

3487. The Jointing and Terminating of High-Voltage Cables.—Holttum. (*Journ. I.E.E.*, May 1937, Vol. 80, No. 485, pp. 517–542: Discussion pp. 543–548.)

3488. A Method for the Elimination of the Energy Loss in the Lead Sheath of Unipolar Cable [using Transformer whose Primary is formed by the Cable and whose Secondary is closed by a Suitable Capacity].—Basile. (*L'Elettrotec.*, 10th April 1937, Vol. 24, No. 7, pp. 196–203.)

3489. A New Thermocouple [Component Wires suitable for Sealing through Glass: Not Attacked by Mercury: a Kovar-Tungsten Couple].—Mason. (*Review Scient. Instr.*, July 1937, Vol. 8, No. 7, p. 265.)

3490. A Sulphur Boiling-Point Apparatus [suitable for calibrating Thermocouples] with Internal Electric Heating.—Barber. (*Journ. Scient. Instr.*, July 1937, Vol. 14, No. 7, pp. 227–229.)

3491. Use of an Alternating-Current Bridge in Laboratory Temperature Control.—Benedict. (*Review Scient. Instr.*, July 1937, Vol. 8, No. 7, pp. 252–254.)

3492. The Micro-Gap Switch.—Thornton. (*Journ. I.E.E.*, May 1937, Vol. 80, No. 485, pp. 457–459: Discussions pp. 468–489.)

3493. Recent Literature on Electrical Contacts.—Windred. (*World Power*, May 1937, Vol. 27, pp. 145–147.)

3494. Investigation on the Melting of Fuses by the Electrographic Oscillograph, *and* The "Mag-Nickel" Fuse.—Keresztes & Selényi: Belling & Lee. (*Elektrot. u. Masch:bau*, 14th March 1937, Vol. 55, No. 11, pp. 122–125.) For the second paper *see* 3302, above.

3495. Arc-Extinction in Granulated Material in High-Voltage Fuses.—Läpple. (*E.T.Z.*, 8th & 22nd April 1937, Nos. 14 & 16, pp. 369–373 and 426–428.)

3496. Coils and Condensers of Negligible Temperature Coefficient.—Thomas. (*Journ. Scient. Instr.*, July 1937, Vol. 14, No. 7, pp. 221–227.) For previous papers *see* 4013 of 1936.

3497. Electrolytic Condensers [including the "Etched" Electrode].—van Geel & Claassen. (*Philips Tech. Review*, March 1937, Vol. 2, No. 3, pp. 65–71.)

3498. Non-Freezing Wet Electrolytic Condenser.—Solar Company. (*Electronics*, July 1937, Vol. 10, No. 7, p. 59.)

3499. On the High-Voltage Polarisation of Certain Electrolytes.—Tvertsyn. (*Journ. of Tech. Phys.* [in Russian], No. 7, Vol. 7, 1937, pp. 712–726.)

In the course of an investigation of electrolytic condensers the author has come to the conclusion that the resistance to breakdown of the oxide layer on the electrodes is determined by the polarisation of the working electrolyte, which may give rise to potentials up to several hundreds of volts. This is disputed by Sakheim in his letter on p. 762.

3500. Electrolytic Polarisation with Alternating Current [investigated by Measurement of Resistance and Capacitance of Electrodes: Explanation based on Diffusion of Ions from the Electrodes].—Christian. (*Phys. Review*, 15th April 1937, Series 2, Vol. 51, No. 8, p. 685: abstract only.)

3501. The Experimental Study of Dielectric Losses and Polarisation in Glasses [Three Components—Structural, Relaxational, and Conductive: Second often masks the Others at High Frequencies: Effect of Metallic Ions, of Crystallisation: etc.].—Skanavi. (*Tech. Phys. of USSR*, No. 4, Vol. 4, 1937, pp. 289–307: in English.)

3502. Graphical Determination of the Electrical Conditions in Coaxial Cylinders with Stratified Dielectric.—Ziegler. (*Arch. f. Elektrot.*, 18th May 1937, Vol. 31, No. 5, pp. 333–337.)

3503. Theory of Electrical Breakdown in Ionic Crystals [Calculations of Time of Relaxation of Electron in Ionic Lattice and Critical Field for Electrical Breakdown: Conditions under which Field increases].—Fröhlich. (*Proc. Roy. Soc.*, Series A, 18th May 1937, Vol. 160, No. 901, pp. 230–241.)

3504. Tests [on Insulators and Dielectrics] with Steep-Fronted Potential Waves.—(*Rev. Gén. de l'Élec.*, 3rd April 1937, Vol. 41, No. 14, p. 446.)

3505. Conducting Electric Charge and Potential Distribution in Transformer Oil.—Okitsu. (*Electrotech. Journal*, Tokyo, July 1937, Vol. 1, No. 2, pp. 65–66.)

3506. Resistance to Breakdown of Liquid and Solid Benzol [Measurements with A.C. Voltage of 50 c/s: Impurities decrease Resistance: Breakdown determined by Voltage Maximum].—Bähre. (*Arch. f. Elektrot.*, 22nd March 1937, Vol. 31, No. 3, pp. 141–165.)

3507. Investigations on the Effect of Artificial Currents of Insulating Oil on Breakdown Voltage [Increase of Voltage due to Presence of Current] and on the Raising of Breakdown Field Strength by Electric Filters.—Conradi. (*Arch. f. Elektrot.*, 22nd March 1937, Vol. 31, No. 3, pp. 179–186.)

3508. The Dielectric Strength of Non-Inflammable Synthetic Insulating Oils.—Clark. (*Elec. Engineering*, June 1937, Vol. 56, No. 6, pp. 671–676.)

3509. The Structure of Dipole Liquids [Theory].—Malsch. (*Ann. der Physik*, Series 5, No. 1, Vol. 29, 1937, pp. 48–60.) Extension of earlier work to explain recent experimental results: discussion of relation to Debye's theory (1089 of March).

3510. Contribution to the Theory and Construction of the "Rolling Armature" Magnet [particularly for Step-by-Step Action].—Frankhauser. (*E.T.Z.*, 8th April 1937, Vol. 58, No. 14, pp. 380–381.)

3511. Single Crystals [of Iron/Nickel Alloy] with Exceptionally High Magnetic Permeabilities [Combination of Factors favouring High Permeability].—Cioffi, Williams, & Bozorth. (*Phys. Review*, 1st June 1937, Series 2, Vol. 51, No. 11, p. 1009: abstract only.)

3512. On the "After-Effect" Loss of Nickel/Iron Alloys [Jordan's "Nachwirkungsverluste," present in addition to "Hysteresis" and "Eddy-Current" Loss in the Total Losses in Ferromagnetic Materials: Dependence on Composition, Heat Treatment, and Temperature: Confirmation of Goldschmidt's "Mixed Constitution" Theory].—Seyffert. (*Zeitschr. f. tech. Phys.*, No. 7, Vol. 18, 1937, pp. 200–203.) For Goldschmidt's work *see* 2417 of 1936, and 1933 Abstracts, p. 112, r-h column.

3513. X-Ray Investigation of Pure Iron/Nickel Alloys: Part 2—Thermal Expansion of Some Further Alloys.—Owen & Yates. (*Proc. Phys. Soc.*, 1st March 1937, Vol. 49, Part 2, No. 271, pp. 178–188.)

3514. Experimental Determination of the Elementary Magnetic Regions of Nickel and Iron. Directed Coagulation of Aerosols II (1).—Beischer & Winkel. (*Naturwiss.*, 25th June 1937, Vol. 25, No. 26/27, pp. 420–423.)

3515. The Ferromagnetic Curie Points and the Absolute Saturation of Some Nickel Alloys.—Marian. (*Ann. de Physique*, April 1937, Series 11, Vol. 7, pp. 459–527.)

3516. Magnetic Hysteresis in 35 Permalloy Sheet at Low Flux Densities [Search for Explanation of "Residual Loss": New Ballistic Method of determining Hysteresis Loop at Low Flux Densities gave No "Residual Loss"].—Ellwood. (*Phys. Review*, 1st June 1937, Series 2, Vol. 51, No. 11, p. 1009: abstract only.)

3517. On a New Alloy "Sendust" [Fe, Si, Al] and Its Magnetic and Electric Properties.—Masumoto. (*Jap. Journ. of Physics*, March 1937, Vol. 12, No. 1, Abstracts p. 30.)

3518. Magnetic Cores for Loading Coils [Subdivision by Gaps in Direction of Field reduces Eddy Currents: Hysteresis and Instability reduced by Gaps Perpendicular to Field, or by Mechanical and Thermal Pre-Treatment: etc.].—Snoek. (*Philips Tech. Review*, March 1937, Vol. 2, No. 3, pp. 77–83.)

3519. Magnetic Properties of Single Crystals of Silicon Iron [Values of Magnetic Isotropy Constants].—Williams. (*Phys. Review*, 1st June 1937, Series 2, Vol. 51, No. 11, pp. 1009: abstract only.)

3520. The Effect of Annealing in a Magnetic Field on the Magnetic Properties of Silicon Steel.—Milner & Klucharev. (*Journ. of Tech. Phys.* [in Russian], No. 4, Vol. 7, 1937, pp. 371–376.)

3521. Magnetic Anisotropy in Silicon Steel [with New Method of Studying], *and* The Relation of Ferromagnetic Anisotropy to Atomic Structure [Theory].—Ingerson & Beck: McKeehan. (*Phys. Review*, 1st June 1937, Series 2, Vol. 51, No. 11, pp. 1009–1010: p. 1010: abstracts only.)

3522. The Magnetic Anisotropy of $Cs_2(CoCl_4)$ [Explanation of van Vleck's Theory].—Krishnan & Mookherji. (*Phys. Review*, 15th March 1937, Series 2, Vol. 51, No. 6, p. 528.)

3523. The External Field of Permanent Magnetic Ellipsoids. Part II.—Neumann & Warmuth. (*E.N.T.*, May 1937, Vol. 14, No. 5, pp. 168–180.)

For I *see* 376 of January. Here calculations are continued to give the external field for the first principal position and for intermediate positions, and also the magnitude of the field at the surface. The results are given in the form of curves for various ellipsoid dimensions and positions of the external point. An experimental method of testing the results is described (apparatus Fig. 3), in which both the ellipsoid and the coil measuring the field can be rotated and separated to any desired degree. Figs. 4, 12 show the good agreement between calculations and measurement. An approximation is also given (§ VII) to the case of permanent bar magnets of rectangular cross-section. It is found that when the radius vector from the centre of the ellipsoid to a distant external point makes an angle 45° with the major axis, the component of the external field parallel to the major axis vanishes.

3524. The Recoil Cycles of Magnet Steels [Data for Various Steels].—Lacoste-Tayan. (*Comptes Rendus*, 24th May & 12th July 1937, pp. 1556–1558 & 122–124.)

3525. Discussion on "The Algebraic Representation of Magnetic Characteristics."—Rougé. (*Bull. Soc. franç. des Élec.*, March 1937, Vol. 7, No. 75, pp. 265–275.) *See* 1217 of March.

3526. The Calculation of the Temperature Coefficient of a Magnet [by writing the Ferromagnetic Equation like van der Waals' Equation of State for a Fluid].—Ashworth. (*Phil. Mag.*, March 1937, Series 7, Vol. 23, No. 154, pp. 355–360.)

3527. Contributions to the Analysis of the Phenomena of Technical Magnetisation: Part II—Importance of the Interaction of the Elementary Regions for the Technical Magnetisation Curves, particularly for Those with Macroscopic Discontinuities.—Weber. (*Zeitschr. f. Physik*, No. 11/12, Vol. 105, 1937, pp. 676–697.)

3528. Properties of the Surface Magnetisation in Ferromagnetic Crystals [Magnetic Powder Patterns on Polished Iron Crystals studied with Macroscopic Model: Effect of Polishing Operation].—Elmore. (*Phys. Review*, 1st June 1937, Series 2, Vol. 51, No. 11, pp. 982–988.)

3529. The Effect of Mechanical Tensions on the Ferromagnetic Properties of Cubical Single Crystals [Calculations].—Schlectweg. (*Ann. der Physik*, Series 5, No. 8, Vol. 28, 1937, pp. 701–720.)

3530. The Magnetic Properties of Manganese Amalgams [Temperature Hysteresis].—Bates & Tai. (*Proc. Phys. Soc.*, 1st May 1937, Vol. 49, Part 3, No. 272, pp. 230–236.)

3531. On the Nature of Coercive Force and Irreversible Changes in Magnetisation.—Kondorski. (*Physik. Zeitschr. der Sowjetunion*, No. 6, Vol. 11, 1937, pp. 597–620: in English.)

3532. Magnetic Inhibition of Susceptibilities [of Paramagnetic Bodies] at Radio Frequencies.—Gorter & Brons. (*Physica*, July 1937, Vol. 4, No. 7, pp. 579–584: in English.)

3533. Paramagnetism at Radio Frequencies [detected by Heterodyne Beat Method: Paramagnetic Specimen inserted into Coil: Behaviour of Alums: Some show Considerable Decrease in Susceptibility when Strong Constant Magnetic Field applied in Direction of Alternating Field].—Gorter. (*Phys. Review*, 1st May 1937, Series 2, Vol. 51, No. 9, p. 778.)

3534. The Diamagnetic Susceptibilities of Salts forming Ions with Inert Gas Configurations: III—The Alkaline Earth Halides and General Discussion.—Hoare & Brindley. (*Proc. Roy. Soc.*, Series A, 1st April 1937, Vol. 159, No. 898, pp. 395–409.)

3535. The Rankine Magnetic Balance and the Magnetic Susceptibility of H_2O, HDO and D_2O.—Iskenderian. (*Phys. Review*, 15th June 1937, Series 2, Vol. 51, No. 12, pp. 1092–1096.) The instrument here described realises the full theoretical sensitivity of the Rankine balance.

3536. A Measuring Apparatus for Magnetic Fields [from 0.1 Gauss upwards, with Accuracy better than 1%: with Motor-Driven Coil, 1 cm in Diameter and Length].—Kohaut. (*Zeitschr. f. tech. Phys.*, No. 7, Vol. 18, 1937, pp. 198–199.)

3537. An Astatic Magnetometer for Measuring Susceptibility.—Johnson & Steiner. (*Review Scient. Instr.*, July 1937, Vol. 8, No. 7, pp. 236–238.)

3538. An Apparatus for Hysteresis Measurements on Soft Magnetic Materials.—Went. (*Philips Tech. Review*, March 1937, Vol. 2, No. 3, pp. 84–86.)

3539. Welding Stainless Steel.—MacKinney. (*Rad. Engineering*, April 1937, Vol. 17, No. 4, pp. 10–12.)

3540. The Rotoroid Multiple Scale [for Electrical Measuring Instruments: Scale rotatable round an Axis, giving Divisions suitable for Several Ranges].—(*Hochf:tech. u. Elek: akus.*, April 1937, Vol. 49, No. 4, pp. 141–142: Industry Review).

3541. The Broadcast Receiver as a Problem of Materials.—Schwandt. (*See* 3298.)

STATIONS, DESIGN AND OPERATION

3542. Automatic Gain Control [AVC Circuit adapted for Semi-Automatic Broadcast-Programme Control].—E. C. Jordan. (*Canadian Journ. of Res.*, June 1937, Vol. 15, No. 6, Sec. A, pp. 79–84.)

"The circuit adjustments for optimum control action were determined experimentally, and then this control action was analysed by means of oscillograms. The effects of different time constants and degrees of control were noted, and methods for varying the latter indicated. The circuit is shown to be distortionless, except in so far as manual control of amplifier gain may be said to introduce 'distortion.' The control action, while not fully automatic [volume contractions occur only on the upper 30 db of the complete 60 or 70 db range: a completely automatic control is not desirable], is complete enough to be of real assistance to the operator."

3543. A Step toward Volume Compression [Western Electric 110-A Programme Amplifier with Automatic Volume Limiter].—(*Rad. Engineering*, June 1937, Vol. 17, No. 6, p. 22.)

3544. Short-Wave Broadcasting.—Ashbridge. (*Rad. Review of Australia*, March 1937, Vol. 5, No. 3, pp. 74–75.) Last of a series of six Empire Broadcast talks: *see* previous numbers of the same journal.

3545. New Broadcasting Stations for Turkey.—(*Marconi Review*, March/April 1937, No 65, pp. 31–32.)

3546. Present-Day Requirements of Commercial Short-Wave Plant: Part 3—Equipment at Central Radio Exchanges for Telegraphy.—Mogel. (*Telefunken* [formerly *Telefunken-Zeitung*], July 1937, Vol. 18, No. 76, pp. 41–50.) For Parts 1 & 2 *see* 1934 Abstracts, p. 337.

3547. A New Method for Diplex C.W. Telegraphy.—Evdokimov. (*See* 3281.)

3548. Aircraft Wireless [on the Air-Liner "Caledonia"].—(*Wireless World*, 16th July 1937, Vol. 41, p. 61.)

3549. "One-Man" Short-Wave Equipment [Knapsack Station for Range of 5 km Telephony, 10 km Telegraphy with Sectional Aluminium-Tube Aerial complete with Loading-Coil Section and Top-Capacity Ribs].—Hofmann. (*Telefunken* [formerly *Telefunken-Zeitung*], July 1937, Vol. 18, No. 76, pp. 66–71.)

GENERAL PHYSICAL ARTICLES

3550. Theory of Recombination of Ions over an Extended Pressure Range [with Equation for Recombination Coefficient].—Loeb. (*Phys. Review*, 15th June 1937, Series 2, Vol. 51, No. 12, pp. 1110–1111.)

3551. The Diamagnetism of the Electron Gas [Calculations showing that Complete Diamagnetism is to be expected for Weak Fields].—Papapetrou. (*Zeitschr. f. Physik*, No. 1/2, Vol. 106, 1937, pp. 9–16.)

3552. Laws of Electromagnetism in Bodies in Motion.—Jochmans & Descans. (*Rev. Gén. de l' Élec.*, 12th & 19th June 1937, Vol. 41, Nos. 24 & 25, pp. 747–760 and 787–793.) Table II shows how the electromagnetic equations derived by the writers differ from those of Hertz and also from those proposed by Lorentz.

3553. The General Motion of a Spinning Uniformly and Rigidly Electrified Sphere: III [Theoretical Determination of Total Mechanical Reaction due to Electromagnetic Field generated by the Motion]: *and* The Uniform Circular Motion with Invariable Normal Spin of a Rigidly and Uniformly Electrified Sphere: IV.—Schott. (*Proc. Roy. Soc.*, Series A, 15th April 1937, Vol. 159, No. 899, pp. 548–570: 570–591.) For I & II *see* 411 of January.

3554. A Note on a Problem in Potential Theory.—Muskat. (*Journ. of Applied Phys.* [formerly *Physics*], June 1937, Vol. 8, No. 6, pp. 434–440.) A summary was referred to in 1629 of 1936.

3555. Matrix Representation of Maxwell's Equations.—Petiau. (*Comptes Rendus*, 7th June 1937, Vol. 204, No. 23, pp. 1710–1713.)

3556. New Form of Born's Electrodynamics without Singularities [with Figure of Hypersurface representing Electron].—Darrieus. (*Comptes Rendus*, 28th June 1937, Vol. 204, No. 26, pp. 1923–1925.)

3557. Generalisation of Aerodynamic and Electrodynamic Fundamental Equations.—Kasterin. (At Patent Office Library, London: Cat. No. 77 568: 66 pp.)

3558. A Method of Solving the Differential Equations of Wave Mechanics.—Schuchowitzky & Olevsky. (*Physik. Zeitschr. der Sowjetunion*, No. 5, Vol. 11, 1937, pp. 498–512: in English.)

3559. The Dispersion of Light in Electric Fields according to the Theory of the Positron: II.—Kemmer & Ludwig. (*Helvet. Phys. Acta*, Fasc. 3, Vol. 10, 1937, pp. 182–184.) For I *see* 2793 of July.

3560. Diffraction with a Large Source (Classic Theory) [Complete Solution].—Wolfers. (*Journ. de Phys. et le Radium*, May 1937, Series 7, Vol. 8, No. 5, pp. 185–192.)

3561. On the Values of Fundamental Atomic Constants [Critical Survey of Experimental Values: Results for Values of Constants with Reasonable Limits of Error].—von Friesen. (*Proc. Roy. Soc.*, Series A, 1st June 1937, Vol. 160, No. 902, pp. 424–440.)

3562. Influence of Electron Number on the Polarisation of the Light emitted by Canal Rays.—Stark & Verleger. (*Physik. Zeitschr.*, 15th May 1937, Vol. 38, No. 10, pp. 357–358.)

3563. The Behaviour of Electrons in Bromine [with Experimental Curves showing Mean Free Path of Electron Drift Velocity, Probability of Attachment, etc.].—Bailey, Makinson, & Somerville. (*Phil. Mag.*, July 1937, Series 7, Vol. 24, No. 159, pp. 177–190.) For similar work on chlorine *see* 1739 of 1935.

3564. Properties of Adsorbed Films with Repulsive Interaction between the Adsorbed Atoms [Theoretical Study].—Wang. (*Proc. Roy. Soc.*, Series A, 1st July 1937, Vol. 161, No. 904, pp. 127–140.)

3565. A Theoretical Formula for the Solubility of Hydrogen in Metals.—Fowler & Smithells. (*Proc. Roy. Soc.*, Series A, 1st May 1937, Vol. 160, No. 900, pp. 37–47.)

3566. Cohesive Forces in Metals, *and* The Exchange of Energy between a Gas and a Solid or Liquid Surface [Surveys of Recent Work].—Mott: Alty. (*Science Progress*, Jan. 1937, Vol. 31, No. 123, pp. 414–424: pp. 436–448.)

3567. The Interaction of Atoms and Molecules with Solid Surfaces: VI—The Behaviour of Adsorbed Helium at Low Temperatures: VII—The Diffraction of Atoms by a Surface: VIII—The Interchange of Energy between a Gas and a Solid: IX—The Emission and Absorption of Energy by a Solid.—Lennard-Jones & Devonshire: Devonshire: Strachan. (*Proc. Roy. Soc.*, Series A, 15th Jan. 1937, Vol. 158, No. 894, pp. 242–252: 253–268: 269–279: 3rd Feb. 1937, No. 895, pp. 591–605.)

3568. On the Choice of the Action Function in the New Field Theory.—Hoffman & Infeld. (*Phys. Review*, 1st March 1937, Series 2, Vol. 51, No. 5, pp. 383–384: abstract only.)

3569. Photoelectric Cross-Section of the Deuteron [Calculations for Exchange and Ordinary Forces].—Way. (*Phys. Review*, 1st April 1937, Series 2, Vol. 51, No. 7, pp. 552–556.)

MISCELLANEOUS

3570. Criticism of Hoover's Paper "Electrostatic Fields and Space Charges about a Conductor."—Zebrovsky & Popkoff: Hoover. (*Physik. Zeitschr. der Sowjetunion*, No. 6, Vol. 11, 1937, pp. 667–668: in English.) *See* 2886 of 1936.

3571. The Potential of a Screen of Circular Wires between Two Conducting Planes [Calculations].—Knight & McMullen. (*Phil. Mag.*, July 1937, Series 7, Vol. 24, No. 159, pp. 35–47.)

3572. Matrix Theory of Multiconductor Transmission Lines [illustrating Power of Matrix Method in Solution of Mathematically Unwieldy Problems].—Pipes. (*Phil. Mag.*, July 1937, Series 7, Vol. 24, No. 159, pp. 97–113.)

3573. The Photoelectric Fourier Analysis of a Given Curve.—G. von Békésy. (*E.N.T.*, May 1937, Vol. 14, No. 5, pp. 157–161.)

This photoelectric method is designed to give a completely automatic record of the separate Fourier coefficients (eqns. 2) of a curve; it is specially suitable for qualitative investigations. A similar arrangement for integrals of more general form has been devised by T. S. Gray (1931 Abstracts, p. 572). The function is represented by the density of darkening of a white surface, while the harmonic component whose amplitude is required is superposed on the surface by a stop of the shape appropriate to the function $\left(1 + {\cos \atop \sin} nx\right)$ (Fig. 3). Light is passed through the surface on to a photocell in series with a galvanometer (Fig. 4), whose deflection gives the Fourier coefficients together with the constant term for $n = 0$ (eqns. 3–5). In order to read off the coefficients directly from the galvanometer deflection, the intensity of illumination or the galvanometer shunt is adjusted so that with the rectangular stop (corresponding to $n = 0$) the pointer is in the middle of the scale. Deflection to left or right thus gives also the sign of the coefficient. Constructional details are given, with the method of representing the function by the degree of blackening of the surface by using a cylindrical lens (Fig. 4). The stops of harmonic shape are drawn on a normal perforated cinema film (Fig. 5), so that the coefficients can be quickly determined in succession. An example of the records obtained is shown in Fig. 7.

3574. "INTRODUCTION TO THE THEORY OF LINEAR DIFFERENTIAL EQUATIONS": *also* "DIFFERENTIAL AND INTEGRAL CALCULUS, VOL. II": *and* "ELEMENTS OF PROBABILITY" [Book Reviews].—Poole: Courant: Levy. (*Science Progress*, July 1937, Vol. 32, No. 125, pp. 156–158.)

3575. INVESTIGATION OF LIMITING CYCLES [in Poincaré's Theory of Non-Linear Differential Equations: General Results on Nature of Regions in Argand Diagram exterior and interior to Limiting Cycles, etc.].—Dulac. (*Comptes Rendus*, 7th June 1937, Vol. 204, No. 23, pp. 1703–1706.)

3576. A METHOD FOR REPRESENTING FOUR VARIABLES IN THREE DIMENSIONS.—Scott. (*Review Scient. Instr.*, July 1937, Vol. 8, No. 7, pp. 248–250.) For example, the dielectric constant of rubber-sulphur compounds as a function of sulphur percentage, temperature, and frequency.

3577. ENGINEERING PROGRESS AND ECONOMIC PROGRESS [Steinmetz Memorial Lecture].—Moulton. (*Gen. Elec. Review*, May 1937, Vol. 40, No. 5, pp. 220–227.)

3578. U.S. DEPARTMENT OF COMMERCE, BUREAU OF FOREIGN AND DOMESTIC COMMERCE: RADIO REFERENCES [List of Books and Pamphlets, U.S.A. and Foreign].—Batson. (At Patent Office Library, London: Cat. No. 77 524: 33 pp.)

3579. THE WRONGFUL USE OF TRANSMITTED ENERGY [Lamps lit in Immediate Neighbourhood of Hamburg Transmitter].—(*Funktech. Monatshefte*, June 1937, No. 6, pp. 192–193.)

3580. "THE NATIONAL PHYSICAL LABORATORY REPORT FOR THE YEAR 1936" [Book Review].—(*Journ. Scient. Instr.*, July 1937, Vol. 14 No. 7, pp. 253–255.)

3581. STYLISTIC INFELICITIES AND THE EXCESS WORD.—Croneis: Urbach. (*Science*, 11th June, 1937, Vol. 85, pp. 562–563.) Criticising Urbach's letter (429 of January) and defending scientific writers.

3582. I.R.E. CONVENTION HIGH-LIGHTS [Some Summaries of the May 1937 Convention].—(*Rad. Engineering*, June 1937, Vol. 17, No. 6, pp. 9 and 12.)

3583. U.R.S.I.–I.R.E. MEETING, WASHINGTON, 30TH APRIL 1937 [Some Summaries].—(*Electronics*, July 1937, Vol. 10, No. 7, pp. 38, 40, 42.)

3584. THE CORONATION: TELECOMMUNICATION ARRANGEMENTS.—(*P.O. Elec. Eng. Journ.*, July 1937, Vol. 30, Part 2, pp. 115–120.)

3585. THE ELECTROMAGNETIC FIELD IN THE REGION OF VERY SHORT WAVES; SPONTANEOUS ROTATING FIELDS [with Bearing on Action on Colloids, etc.].—Krasny-Ergen. (*Hochf:tech. u. Elek:akus.*, June 1937, Vol. 49, No. 6, pp. 195–199.)

Previous theoretical work of the writer (787 of February) is here illustrated by the example of "the introduction of a homogeneous, infinitely long cylinder into a homogeneous medium originally containing a homogeneous alternating field perpendicular to the cylinder axis. It is found that, in a certain frequency range, the field external to the cylinder is quite different in different phases," so that the lines of force cannot be represented by one diagram only. The occurrence of spontaneous rotating fields is discussed, with the bearing of the results on the action of electromagnetic fields on colloids, etc.

3586. "ULTRASONS ET BIOLOGIE" [Book Review].—Dognon & Biancani. (*Alta Frequenza*, July 1937, Vol. 6, No. 7, p. 483.)

3587. DISTURBANCE-FREE TRIPLE CARDIOGRAPHY [Star Connection, with Three Cathode-Ray or Loop Oscillographs], *and* NEW ELECTROCARDIOGRAPHIC RECORDING METHODS [and the "Three-Phase Vector Field of the Electrical Heart Axis": the Use of the "Triograph" Cathode-Ray Oscillograph with Three Deflecting Plates arranged in form of Triangle].—H. E. Hollmann: H. E. & W. Hollmann. (*Zeitschr. f. Instrumentenkunde*, Nos. 3 & 4, Vol. 57, 1937, pp. 117–124: pp. 147–167.)

In the second paper the author writes: "Comparison of the 'triograms' obtained by the new method with the previous two-phase Lissajous' figures shows important differences, which are explained by means of a model test in the electrolytic trough."

Some Recent Patents

The following abstracts are prepared with the permission of the Controller of H.M. Stationery Office, from Specifications obtainable at the Patent Office, 25, Southampton Buildings, London, W.C.2, price 1/- each. A selection of abstracts from patents issued in the U.S.A. is also included, and these bear a seven-figure serial number.

AERIALS AND AERIAL SYSTEMS

464 789.—Wireless aerial for motor vehicles with a flexible mounting designed to "give" without breaking on coming into contact with a tree or similar obstacle.

Marconi's W.T. Co. and E. H. Trump. Application date 24th October, 1935.

TRANSMISSION CIRCUITS AND APPARATUS

463 236.—Magnetron oscillator in which the divided anode forms part of a resonant concentric circuit.

Telefunken Co. Convention date (Germany) 15th August, 1935.

463 238.—Means for modulating a high-frequency wave as it is propagated along a "dielectric-guide-line."

Standard Telephones and Cables (assignees of G. C. Southworth and A. P. King). Convention date (U.S.A.) 12th October, 1935.

465 482.—Electron-oscillator valve for generating very-short waves at a high level of power.

Marconi's W.T. Co. (assignees of C. W. Hansell). Convention date (U.S.A.) 28th November, 1934.

RECEPTION CIRCUITS AND APPARATUS

462 832.—Automatically controlling the selectivity of a receiver in accordance with the strength of unwanted signals.

Murphy Radio and L. A. Moxon. Application date 18th September, 1935.

463 006.—Method of coupling circuits so as to ensure a constant response over a wide band of frequencies.

The General Electric Co. and J. J. E. Aspin. Application date 20th January, 1936.

463 070.—Method of suppressing image frequencies in a superhet receiver.

Marconi's W.T. Co. and A. T. Witts. Application date 21st September, 1935.

463 233.—Method of automatic selectivity control based upon regenerative feed-back from one of the amplifiers to an input circuit of the band-pass type.

Marconi's W.T. Co. (assignees of J. Plebanski). Convention date (Poland) 7th October, 1935.

463 393.—Combination of air-cored and iron-cored coils and condenser forming a compact tuning unit for a wireless receiver.

The General Electric Co. and R. W. Speirs. Application date 26th November, 1936.

463 748.—Circuit arrangement for "muting" a wireless receiver of the superhet type.

E. K. Cole. Application date 12th December, 1935.

464 609.—Compensating for frequency-variations in the local-oscillator valve of a superhet receiver.

Radio-Akt. D. S. Loewe. Convention date (Germany) 19th July, 1935.

465 176.—Receiver in which the selectivity is temporarily increased in order to facilitate accurate tuning.

E. K. Cole and G. Bradfield. Application date 5th November, 1935.

465 282.—Method of cutting-out interference from a superhet receiver by periodically "quenching" the intermediate-frequency stage.

The Plessy Co.; C. E. G. Bailey and G. Baillie. Application date 19th November, 1935.

465 515.—Receiver with automatic fine-tuning operated through a variable-mu valve controlled by the incoming signal.

J. Robinson. Application date 7th October, 1935.

VALVES AND THERMIONICS

463 241.—Rigid electrode structure suitable for the mass production of multi-electrode valves.

Rogers Radio Tubes. Convention date (U.S.A.) 20th May, 1936.

464 430.—Construction and assembly of the electrode system of a cathode-ray tube.

Standard Telephones and Cables. Application date 18th October, 1935.

465 334.—Electrode assembly for a valve including an anode of graphite or carbon for dissipating heat.

Standard Telephones and Cables (assignees of D. A. S. Hale and V. L. Ronci). Convention date (U.S.A.) 9th January, 1936.

465 483.—Horse-shoe cathode construction for a valve of the electron "beam" type.

Marconi's W. T. Co.; N. M. Rust; and G. F. Brett. Application date 7th November, 1935.

DIRECTIONAL WIRELESS

462 843.—Short-wave aerial system for transmitting overlapping beams of radiation to mark out a navigational course.

Soc. Industrielle; W. A. Loth. Convention date (France) 31st October, 1934.

463 052.—Directional aerial system arranged to give maximum reception along a selected vertical angle of incidence.

R. A. W. Watt. Application date 19th September, 1935.

TELEVISION AND PHOTOTELEGRAPHY

462 683.—Magnetic shield for the focusing coil of a cathode-ray tube.

A. H. Gilbert; L. R. Merdler; G. R. Tingley; and Baird Television. Application dates 12th and 23rd September, 1935.

462 877.—Television system in which a number of picture points are transmitted and received simultaneously.

Standard Telephones and Cables (assignees of Le Materiel Telephonique Soc. Anon). Convention date (France) 8th June, 1935.

462 929.—Television transmitter designed to maintain the correct "mean" value of picture illumination.

Radio Akt., D. S. Loewe. Convention date (German) 28th February, 1935.

463 210.—Method of varying the intensity of the electron stream in a cathode-ray tube of the cold cathode type.

W. Rogowski. Application date 6th December, 1935.

463 255.—Multi-vibrator circuit for generating the synchronising and scanning impulses used in television.

Marconi's W.T. Co. (assignees of J. P. Smith). Convention date (U.S.A.) 18th October, 1934.

463 297.—Cathode-ray tube suitable for the transmission of pictures in which the photo-sensitive screen is coated with zinc selenide.

H. Miller. Application date 24th September, 1935.

463 318.—Television system in which an additional band of modulation frequencies is utilised to represent slow changes in the background illumination of the picture.

Hazeltine Corp. (assignees of H. M. Lewis). Convention date (U.S.A.) 5th October, 1934.

463 642.—Method of mounting the fluorescent screen on the bulb of a cathode-ray tube.

Ferranti and M. K. Taylor. Application date 3rd October, 1935.

463 829.—Controlling the output from a cathode-ray tube of the so-called "image-dissector" type as used in television.

Farnsworth Television Inc. Convention date (U.S.A.) 13th March, 1935.

464 483.—Television system in which both picture signals and synchronising impulses are derived from the same photo-electric cell, and in which the synchronizing impulses reduce the carrier output to zero.

Radio-Akt., D. S. Loewe.

465 055.—Television circuit for generating two different scanning frequencies from a single discharge valve.

Baird Television and E. E. Wright. Application date 29th October, 1935.

465 184.—Mechanical scanning system designed for the interlaced scanning of a film.

Radio-Akt., D. S. Loewe. Convention date (Germany) 4th September, 1934.

465 405.—Television receiver in which the coupling to the detector is so arranged (*a*) that a negative picture can be converted to a positive one, and (*b*) it has no appreciable damping effect on the detector input.

Ferranti and M. K. Taylor. Application date 2nd October, 1935.

464 610.—Preventing interference effects in television due to the prolongation of the "flyback" period in scanning.

C. Lorenz Akt. Convention date (Germany) 23rd August, 1935.

465 642.—Optical focusing system for a rotating-disc scanner as used in television.

E. Traub. Application date 26th February, 1936.

SUBSIDIARY APPARATUS AND MATERIALS

463 676.—Construction of screening device for H.F. coils with means for minimising the production of eddy-currents.

G. Fodor; J. Toutain; and M. Bloch. Convention date (France) 17th October, 1935.

463 724.—Iron-cored high-frequency coils tuned by their inherent capacity.

S. G. Brown. Application date 30th August, 1935.

463 734.—Loud speaker with independent means for controlling the air pressure in the vicinity of the vibrating diaphragm.

R. R. Glen. Application date 4th October, 1935.

464 268.—Electrode system with unsymmetrical conductivity suitable for a dry-contact rectifier, or a light-sensitive cell.

N. V. Philips Co. Convention date (Germany) 22nd November, 1935.

465 266.—Cathode ray tube in which the electron stream is produced by bombardment of the cathode.

Ferranti and J. C. Wilson. Application date 3rd October, 1935.

MISCELLANEOUS

463 061.—Light-sensitive devices of the "electron-multiplier" type.

Baird Television and J. R. H. Forman. Application date 20th September, 1935.

463 253.—Deriving D.C. potentials from an A.C. source for the electrodes of a cathode-ray tube.

Marconi's W.T. Co. (assignees of A. W. Vance). Convention date (U.S.A.) 29th September, 1934.

463 666.—Microphone-amplifier for a portable deaf-aid appliance.

Sonotone Corp. (assignees of H. A. Pearson and E. C. Nicholides). Convention date (U.S.A.) 4th October, 1934.

464 278.—Suppressor resistances for preventing H.F. radiation from the ignition system of a motor-car fitted with a wireless set.

F. R. F. Ramsay. Application date 10th October, 1935.

465 129.—Wireless-controlled traffic signal or indicator for motor cars and other moving vehicles.

E. G. F. Winkler and H. de Csarada. Application date 1st November, 1935.